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VICTORIA.

# DEPARTMENT OF MINES.

# RECORDS

OF THE

# GEOLOGICAL SURVEY OF VICTORIA.

(H. HERMAN, B.C.E., M.M.E., F.G.S., Director.)

## Vol. IV., Part 1.

BRITISH MUSEUM
GEOLOGICAL DEPARTMENT

ISSUED BY

W. DICKSON, SECRETARY FOR MINES, UNDER THE AUTHORITY OF THE HON. A. DOWNWARD, M.L.A., MINISTER OF MINES.

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6318.—Price 1s. 6d.

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CORRIGENDA FOR "NEWER SILURIAN FOSSILS OF EASTERN VICTORIA. PART III." REC. GEOL. SURV. VICT., VOL. III., PT. 3, 1914, PP. 301–316.

Page 301—Line 2 from top, for "Par" read "Part".
„ 20 from bottom, for "(Loyolophyllia)" read "(Loyolophyllum)".

Page 313—Line 7 from top, for "Receptatudtes" read "Receptaculites".
„ 8 „ „ "Zaphrenisma" „ "Zaphrentis".
„ 9 „ „ "Tryplalisc" „ "Tryplasma".
„ 16 „ „ "Gold.f" „ "Goldf".
„ 22 „ „ "suborbicuaris" „ "suborbicularis".

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CORRIGENDA TO "CAINOZOIC GEOLOGY OF THE MALLEE AND OTHER VICTORIAN BORES." REC. GEOL. SURV. VICT., VOL. III., PT. 4., 1916.

Page 328—Line 18 from top read "the South Australian boundary about 6 miles east of Pinaroo".

Page 396—Delete last line and add "No fresh water was struck in this bore. Water was previously recorded through error in foreman's report".

Page 408—Second line from top, for "hydraulic surface" read "hydraulic layer".
and in diagram fig. 42, under dotted line, for "Freshwater hydraulic surface" read "Limiting surface of Janjukian water-bearing beds".

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# THE DISCOVERY OF FOSSILS IN THE GRAMPIAN SANDSTONES WITH GENERAL NOTES ON THE FORMATION.

*By W. H. Ferguson, Assistant Field Geologist.*

The Grampians are, for the most part, formed of a great mass of sandstones, the age of which has long been in doubt, as no fossils had been obtained there. In places, there are outcrops of granodiorites and porphyries, and the relation of these rocks to the sandstone series has not been proved.

The sediments generally are thick-bedded, coarse-grained sandstones, but in a few places there are finer beds, and quartzites and conglomerates also occur.

The sandstones form rugged mountain ranges generally trending about north and south with the strike of the rocks. Where massive sandstones have a moderate dip, one side of the range generally has an easy slope which approximates to the angle of dip, the other presents an almost vertical cliff or escarpment. The fine scenery of the Grampians is due to long-continued weathering acting along strike and dip, and three systems of joint planes.

## Fossils.

Search for fossils was restricted to the finer-grained rocks ; thinly-bedded shales, &c. of this character are interbedded with the sandstones in Hall's Gap, allotment No. 6G, parish of Boroka. In them, what appear to be sun cracks are numerous, so I have called the hitherto unnamed gully in which they outcrop, Suncrack Gully. Though these rocks have a likely appearance for fossils, none could be found in them ; this was also the case with a fine lot of beds 150 ft. in thickness which were searched in Dairy Creek, and which may be an extension of the Suncrack Gully beds.

A very limited quantity of fine-grained rocks occur on the side of Mount Rosea (The Goat Rock) at the head of Stony Creek, and here I found fossils.

Fine-grained chocolate shales form portion of the Mount Don range between Mount William Creek (Little Wimmera) and Talbot's Gap, near Mount William, and in these beds was discovered what is apparently the track of a crustacean.

At Mount Rosea the fossils occur in a dark red or purplish shale, the outcrop of which has been cut by the tourist track which has recently been made from the dredge on Stony Creek up the side of the mountain. Near the top there is a natural track formed by a fault and dyke, and known as the Stairway, and just below this the fossils were found in a bed not more than half an inch in thickness, which was traced along the strike for about 5 feet.

The fossils from this place identified by Mr. F. Chapman, A.L.S.,[1] consisted of spines of fishes and a small Lingula. He considers they are undoubtedly Lower Carboniferous.

## The Relation of the Grampian Sandstones to the Igneous Rocks.

From general field evidence it appears that the granodiorites and porphyries are intrusive into the sandstones. This conclusion is based on the following evidence :—

1. Near the granitic rocks, the sandstones are, in many places, altered into quartzites.
2. In some places, small dykes appear to extend from the granodiorite into the sandstones.

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[1] See page 83.

3. True quartz veins in the sandstones have been noted only close to the contact of granodiorite or porphyry.
4. No conglomerate containing granitic boulders, or quartz derived from granitic rocks, was found at the base of the sandstones where they rest directly on granodiorite.

Good junctions between the sandstones and porphyry were examined at Stony Creek and at the falls, McKenzie Creek; and the contact of the granodiorite and sandstone was inspected at Wartook, Stony Creek, and Mount William goldfield. An area of granitic rock at Chimney Gap has been viewed, but not examined.

*Wartook.*—From the Wartook Reservoir an unused bush road extends to Rosebrook Station; on it, about 3 miles from the caretaker's cottage, there is a contact between granodiorite and Grampian sandstones. The latter are somewhat abnormal; some are silicified, but quartzite here is not a prominent feature. In the sandstones are bunches of quartz crystals and veins of quartz, and an old shaft on the road has been sunk on a quartz vein which is said to have contained gold. True quartz veins are very rare in the Grampian sandstones, though small, siliceous pipes and veins are plentiful in some parts. In the sandstones there also occur irregular veins of specular iron ore, and a porphyrytic dyke, which was traced close to the contact of the granite rock; a similar dyke was observed in the granodiorite at its junction with the sandstones.

*Stony Creek.*—On the north and east sides of the granodiorite, the sandstones have been altered to very vitreous, brittle, and shattered quartzites, which stand out like a wall. The actual contact here is unfortunately obscured by alluvium. A considerable amount of gold has been obtained at, and near, this portion of the contact.

*Mount William Goldfield.*—There is a larger area of granodiorite exposed at Mount William than at Stony Creek. On the eastern boundary, the Coronation tunnel, which has been driven westerly into Sugarloaf Hill, at first intersects sandstones and then continues for a considerable distance in granodiorite. The contact of the two rocks is not as clear as could be desired, since there has been a considerable amount of crushing, but the granodiorite here certainly appears to alter the sandstones and to throw off small dykes into them.

In the same district but nearer Mafeking, there is a large area of quartzite on the saddle at the head of the Mount William or LittleWimmera Creek.

It should be mentioned that only in one locality (the Saddle, Mafeking) were quartzites found at more than half a mile from a granitic outcrop, and in this instance, it is not known at what depth below the surface the igneous rock may exist.

From my own observation, and from inquiries, it appears that quartzites are rare in the Grampians, and it seems very likely that where found they are the result of contact metamorphism of igneous rocks.

*Other Igneous Rocks.*—Along the mining track from Hall's Gap to the head of the Stony Creek, there are several outcrops of porphyry. These appear to have been thrust into sandstones, generally along the bedding planes, and in places the last inch or so of the sandstone adjoining the porphyry has been altered to a more or less vitreous quartzite.

At the Stairway, on the face of Mount Rosea, the sandstone beds are diagonally intersected by a decomposed porphyry dyke which occurs in a strong fault, and apparently slightly indurates the sandstones.

Along the new track from Hall's Gap to the Gates of the West there are several outcrops of porphyry, and further south along the range past Wonderland there is a larger mass of similar rock, with quartzite on its eastern contact.

Just below the retaining wall of the Wartook Reservoir, a dense, dark-blue basic rock occurs in the Grampian sandstones, but the surface here is marshy, and the relation of the rocks was not observed. At the Broken Falls, McKenzie Creek, a fine contact, in plan, between Grampian sandstones and porphyry was noted; and, at the foot of the Big Fall, a vertical contact is very clearly exposed; in both places the porphyry certainly appears to be intrusive. Hand specimens of some of the actual contacts are exhibited in the Geological Survey Museum.

## Extent of the Grampian Sandstones.

The main mass of the Grampian sandstones outcrops between Mount Zero on the north, Dunkeld on the south, Moyston on the east, and Cavendish on the west, with outlying portions on the west at the Dundas and Black Ranges, and at Mount Arapiles. To the south a small outcrop occurs near Wickliffe which probably marks the southern limit of the formation in that locality as it consists of a boulder-conglomerate in which stones up to a foot in diameter were noted.[1] It was probably deposited on a shore line of Ordovician rocks, portions of which are included in the conglomerate. This is the southern limit in this locality, but, southwards from Dunkeld, the sandstones may extend under the Tertiary basalts towards the coast.

West of the Dundas Range, most of the sandstones—if they ever existed—have been removed by denudation, for older rocks outcrop in many places in this direction.

R. A. F. Murray,[2] formerly Government Geologist, has given some notes on the Grampian sandstones and their northern extension.

"That these Grampian sandstones extend under the Tertiary deposits of portion of the North-Western District has been proved by a bore at Netherby, near Nhill, to a depth of 2,200 feet. The cores obtained below the Tertiary deposits consist of nearly horizontally bedded, laminar shales sandstones, conglomerates, and breccias.

"The conglomerates contained boulders of gneissose schist and granite and yielded in some cases a trace of gold on assay. The bore left off in porphyry, but whether an intrusive mass underlying the sedimentary strata or a layer interbedded with them is not known.

"It is evident, however, that the rocks of the Grampian sandstone series extend north-westerly beyond their northernmost exposures near Horsham and Mount Arapiles, a long distance towards the Murray."

Murray further states that from the results of boring operations extending from near Donald towards Lake Tyrrell, the Ordovician rocks of Wedderburn extend north-westerly towards that lake and would limit the eastward extension of the Grampian formation so far north, but, further south, he does not consider that the sandstones extend further east than a line from Horsham to Lake Boga. The utmost possible western limit he considers to be the granite of the Coorong, South Australia.

Apparently, the now visible Grampian sandstones are but a remnant—which has escaped denudation—of a once widespread formation.

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[1] W. H. Ferguson, Prog. Rept. Geol. Surv., Vict., No. IX., 1889, p. 175.
[2] Annual Rept. Sec. for Mines, 1889, p. 18.

The trough in the older Palæozoic rocks in which the Grampian sandstones were deposited appears to get deeper from south to north, for the basal conglomerates of Greenvale reach the surface, but at Murra-Warra, near Horsham, a bore proved Ordovician at 400 feet from the surface, while further north in the Netherby bore referred to (between Nhill and Lake Hindmarsh) Older Palæozoic strata were not reached in a bore 2,200 feet deep.

## The Source of the Gold obtained in the Grampians.

Several writers have expressed opinions on the origin of the gold found in the Grampians.[1]

The gold which has been obtained in payable quantities appears to be very closely associated with the granodiorite, and, with one possible exception, more or less gold has been obtained wherever granodiorite outcrops in the Grampians. The largest quantity has been secured from the Mount William goldfield, where over 25,000 oz., all in pieces weighing less than 2 dwt., is said to have been raised from alluvial wash mostly under 30 feet in depth. There is another but smaller goldfield at Stony Creek, 4 miles from Fyan's Creek, at Hall's Gap; a considerable amount of gold has been obtained here from shallow alluvial workings, and a dredge was built but is now abandoned.

I lately visited the Coronation mine and Wright's lode on the Sugarloaf Hill, Mount William, and noted several points of interest.

The Coronation lode, which has been proved to 300 feet from the surface, is in granodiorite. There are two tunnels, the lower out of repair.

The lode varies considerably in size and composition; in some places it is not more than 2 inches thick and in others it has been taken out over a foot wide; in different parts it ranges from a vein of rather vitreous quartz to a vein of limonite, or it may assume the form of quartz through which are small bands of quartz and felspar crystals. I was informed by the manager, Mr. A. Pottage (who showed me over the mine, and to whom I am indebted for assistance and information) that when consisting of quartz, the lode was almost barren, and when formed of ironstone, it was small but rich; the gold was probably deposited with iron sulphide which has decomposed to limonite.

In the upper tunnel of the Coronation mine, the lode consists of a decomposed granodiorite which differs in appearance but little from the ordinary decomposed granodiorite; it appears to be an impregnation along a fissure or track and the altered portions occur at irregular intervals. Possibly, solutions travelling along the track have altered the granodiorite for a few inches on either side, and in this altered portion gold has been deposited. Almost identical occurrences have been noted at the Mount Deddick silver-lead field, where fissures traverse the granodiorite and the rock on one or both sides of them is altered for varying distances, and the altered portions contain a small amount of galena and other minerals which do not occur in the unaltered rock.

On the Sugarloaf Hill is Wright's lode, which also traverses granodiorite; it consists of granitic matter and possibly the lode material has been altered by siliceous and felspathic solutions which have passed along one or more movement planes. It is about 4 feet thick and dips in a westerly direction at about 10°. A shoot of more auriferous stone, 5 to 10 feet in length, has

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[1] Special Report on Mt. William Gold-field by H. Herman, Dept. Mines, Vict, 1900; Report on Auriferous Discoveries, Grampians, by J. Stirling, Prog. Rept. Geol. Surv. Vict., No. XI. 1899; Mt. William Gold-field, Grampians, by E. J. Dunn, Rec. Geol. Sur. Vict., Vol. III., pt. 2, p. 118, 1912; Report on Proposed Boring Sites, Boggy Creek, Mt. William Gold-field, by A. M. Howitt, Rec. Geol. Surv. Vict. Vol. III., pt. 2, p. 117, 1912 Report on Stony Creek, near Hall's Gap, Grampians, by E. J. Dunn, Rec. Geol. Surv. Vict., Vol. III., pt. 2, p. 116, 1912.

been worked northwards down the dip and pitch. The lode contains dense siliceous granitic veins traversed by very small veins of clear vitreous quartz. I was informed that, for a time, the lode was worked at a profit.

Between the Sugarloaf Hill and Mafeking, in Ferny Creek, quartz veins with granitic matter occur along a movement plane in granodiorite. A little work has been done, and the veins are stated to be auriferous. The lode is about 1 foot thick; on the foot wall there is 4 inches of fairly solid quartz, and the rest consists of granitic matter and some quartz, with vughs which contain quartz crystals. The strike is north and south, and the dip is east at 60°.

At Mafeking, gold has been obtained in veins in the granodiorite, but these occurrences have not been inspected by the writer.

Payable gold has been obtained at Stony Creek, Hall's Gap, in the alluvium resting on granodiorite. Unfortunately, very little of the granodiorite can be seen, as it is covered by old workings, and at the dredge by water. I was informed by Mr. F. D'Alton, the discoverer of the field, that the granodiorite is intersected by a small "clay seam" which is regarded as having been the source of some of the gold obtained. Mr. D'Alton showed me an interesting sample of wire gold, and some gold in small octahedral crystals.

The probable source of the small amount of alluvial gold which is said to have been obtained at the Wartook Reservoir, is not known to the writer. Rose's Gap was not visited, but it is reported by Mr. G. Carter, of Rosebrook Station, that "granite" exists there, and that gold is obtained in dish prospects on the side of the range. It seems strange that no gold has been obtained at the large area of igneous rocks in the Victoria Valley, north of Dunkeld; an inspection would show whether the rock is granodiorite, and if any prospecting has been done.

## Minerals.

At Mount William goldfield numbers of quartz crystals are found in the wash; some are much waterworn, others are sharp and angular, some are clear and without colour, and others are almost black. A number of amethystine crystals, some beautifully coloured, were presented to the Geological Survey Museum by Mr. W. Browning, of the Prospector's Claim, Mafeking. The miners consider the amethysts have been derived from the granodiorite of the field, and, as they occur with the best gold the point is interesting. Amethystine quartz crystals were obtained from veins in the Grampian sandstones, in the vicinity of igneous intrusions at the Wartook Reservoir.

At Mount William, molybdenite occurs as splashes coating joint planes in the granodiorite, and is generally accompanied with a few crystals of iron pyrite. Nothing like a lode of it was noted.

Specular iron ore, or micaceous hæmatite, was collected on the old road from Wartook to Rosebrook near an old shaft about 3 miles from the Wartook Reservoir. A vein about 1 foot thick occurs in the Grampian sandstones near their junction with granodiorite. There are other small deposits of the mineral, but it does not appear to exist in commercial quantity.

I desire to acknowledge much assistance in my work by the Messrs. J. F. and C. D'Alton, of Hall's Gap, and by Mr. G. Carter, of Rosebrook.

[24.2.13.]

## SHELL SAND IN THE WARRNAMBOOL DISTRICT.

*By D. J. Mahony, M.Sc., F.G.S., Petrologist.*

Between Warrnambool and Port Fairy, a distance of about 15 miles, the coast is fringed by extensive sand-dunes, which vary in width from 100 yards to a quarter of a mile or more, and rise to an average height of about 50 feet. Very probably they extend beyond the places mentioned. These dunes are formed of loose sand, which moves with every breeze, and they are now devoid of natural vegetation, though there are signs that at one time a part, at least, was covered with tea-tree scrub. A good deal of marram grass has been planted to prevent the sand from shifting and encroaching on the rich volcanic soils, but the available evidence indicates that there has been very little movement since the country was occupied.

The important feature about these dunes is that in many places they consist almost entirely of small pieces of sea shells, which have been broken up by the waves and then blown by the wind to their present position. This sand has, indeed, the composition of a fairly pure limestone. An average sample gave the following results on analysis :—

| | per cent. |
|---|---|
| $CaCO_3$ ... ... ... ... | 86·25 |
| Insol. ($SiO_2$)... ... ... ... | 5·10 |
| $Al_2O_3$ ... ... ... ... | 0·57 |
| $Fe_2O_3$ ... ... ... ... | 0·87 |
| $MgCO_3$ ... ... ... ... | 6·64 |
| NaCl ... ... ... ... | present in small quantity. |
| $P_2O_5$ ... ... ... ... | do. do. |
| $H_2O$ ... ... ... ... | 0·41 |
| | 99·84% |

The 6.64 per cent. of magnesium carbonate is higher than might be expected.

There is here, then, a deposit of many millions of tons of finely-divided limestone, apparently in a form suitable for agricultural purposes. The value of crushed limestone as a fertilizer has been the subject of elaborate investigation by the United States Department of Agriculture for the past 25 years, and its use, when applied to certain soils, has been abundantly proved. In a report (Farmer's Bulletin No. XL., 1907), it is stated that calcium carbonate (limestone) gave decidedly better results than caustic lime (quicklime), and that the application of shell marl produced more grain and fodder than either stone lime or oyster-shell lime ; and that it is cheaper and much more effective than gypsum. In certain of the States the railway companies carry limestone at very low rates, because it is realized that the general prosperity of these companies is bound up with the fertility of the soil.

The beneficial action of limestone upon soils may be chemical or physical, or both. The chemical action consists directly in supplying lime, in which many soils are deficient, or, indirectly, in neutralizing the acidity ; the physical action takes the form of keeping the soil open and porous. In Victoria the agricultural value of many good soils is handicapped by their acidity, especially in reclaimed swamps or districts where cattle have been grazed for many years, and in irrigated areas the pores of the soil tend to become clogged, so that a more or less impervious layer is formed ; in these cases the application of limestone should be most beneficial, but hitherto the high cost of limestone and lime has prevented its extensive use.

The shell sand of Warrnambool is close to the railway, and could be reached by sidings. Should the demand warrant the use of steam shovels,

or other mechanical appliances, the sand could be loaded into the trucks at a trifling cost. The cheapness with which such material can be handled in quantity may be gauged from the results obtained by gold dredges, which can raise to a considerable height, wash and redeposit a cubic yard of sand and gravel weighing about 1 ton, at a cost of 2d. Before any operations of this nature are undertaken experiments should be made with the sand, and the dunes should be thoroughly examined and sampled to determine the relative values of the various parts.

[18.4.12.]

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## PYRENEES PROPRIETARY MINE, REDBANK.

*By W. Baragwanath, Senior Field Geologist.*

The Pyrenees Proprietary mine is situated at Redbank, a small hamlet about fifteen miles north-west of Avoca. In the early sixties, Redbank, which now comprises about a score of houses, was a busy mining centre, from which large gold escorts were weekly despatched.

The alluvial gullies trending easterly from the Pyrenees Range through Redbank towards the Avoca River provided numerous nuggets. Endeavours to locate the source of these nuggets resulted in the discovery of several quartz reefs, one of which, the Pyrenees, now embraced within the lease of the mine under review, proved highly profitable.

Records of the earlier workings, while not complete, are fortunately preserved in the Departmental reports on Neglected Gold-fields (1894), and also in the reports of the Mining Surveyors and Registrars (see Appendix A). The earlier returns from the prospecting and adjacent claims in 1861 show that they were highly payable to water-level. A few extracts taken from the above-mentioned reports may be cited:—"From the prospecting claim 1,200 oz. were quickly taken . . .; in No. 1 south 600 oz. were obtained . . .; in No. 2 south the gold was struck at 10 feet from the surface, and when the water was reached at 140 feet 700 oz. had been obtained . . .; in No. 3 the owners took out 600 oz. . . .; in No. 4 claim 1,600 oz. were obtained between a depth of 80 and 175 feet; at the latter depth, owing to heavy water, the claim was abandoned . . . .; in No. 5 claim at 100 feet they struck a well-defined reef 3 feet thick which averaged 5 oz. to the ton, and which they carried down another 75 feet, when the water stopped further operations . . .; they won 1,700 oz. from this little claim, the last shot put in enabling them to get 150 oz. of gold . . .; in four claims still further south a total of 7,000 oz. were obtained, the greatest depth on the reef being 210 feet in No. 7; very rich stone was obtained in places in the shallow workings on the reef." From the report mentioned above the following is taken:—"75 lb. of quartz gave 124 oz. . . .; 15 cwt. of stone yielded 500 oz., while from the tailings another 88 oz. were obtained."

In 1862 a quartz specimen found in the Pyrenees reef yielded 36 oz. A single ton from No. 2 south gave 193 oz. From No. 5 claim one ton gave 201 oz. Averages of 3 oz. to 5 oz. to the ton for parcels of 50 and 60 tons were common in 1862 and 1863. In 1865 the Pyrenees as well as adjacent reefs were abandoned, and notwithstanding the rich yields and the prospects of further developments no work was carried out until late in the nineties, when the New Pyrenees Gold Mining Company started work, sank the present main shaft to a depth of 333 feet, and at 250 ft. and 325 ft. drove levels. No. 13

shaft was repaired and a trial crushing taken from a south drive at a depth of 180 feet from surface, 20 tons yielding 5 dwt. of gold per ton. Early in 1909 the Pyrenees Proprietary Gold Mining Company (the present) commenced operations. With varying success and a short cessation, work continued to the present date, on the quartz reefs below water-level. The workings now consist of a main shaft 94 feet westerly from the former No. 5 south shaft, sunk to a depth of 435 feet, having three compartments to a depth of 325 feet and four below. Levels were opened out at 250 ft., 325 ft., and 425 ft. below the sill, and drives chiefly southerly, extended along the line of lode. Two distinct reefs have been exploited. Of these the eastern formation has been worked from the 250 ft. level upwards and has connected with shallow shafts of the early miners. The western formation, on which the 350 ft. level has been driven, lies about 30 feet west of the eastern body. Extensive stoping above the 350 ft. level reaches to some height above the 250 ft. level, and for a length of over 300 feet. At the 425 ft. level the position of the western formation had not been found, and the present survey was carried out to locate it.

The structure of the mine reveals a series of west-dipping beds of alternate sandstones and slates, all highly metamorphosed (apparently regionally), with laminated quartz lodes varying from a thread up to several feet in thickness and conforming in strike and dip to the enclosing strata. Occasionally the quartz gives out completely leaving only a track or "back." At the bottom level (425 ft.) a crushed lode track up to a foot wide was driven on for nearly 700 feet without any sign of quartz making in it. The general dip of the strata is from 55° to 60° W. with a strike of N. 35° W. (magnetic). Nodular and graphitic slates are common and appear to predominate over the sandstones in the belt mined.

Intersecting the strata with a decidedly southerly dip are a number of dykes which, where they cut the quartz reefs, appear to play an important part in the metalliferous character of the stone. While these dykes are commonly nearly horizontal they are at times found interlaminated with the lodes. In composition the dykes appear to belong to the diorite or lamprophyre series and are similar to those in the Maryborough district where their presence in association with auriferous quartz has been noted by Mr. A. M. Howitt.[1]

Slipping on bedding planes is common apart from the backs noted above. On these slip-planes slicken-sided or grooved surfaces were noticed. A roll occurs in the strata which produces a marked effect in the width of the lode. This roll is exposed in a cross-cut 150 feet south of the shaft at the 250 ft. level (Fig. 1), while in the 325 ft. level the roll shows up in the stopes on the western lode at 530 feet south of the shaft.

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## Notes on the Mine Workings.

*No.* 1 (250 *ft.*) *level.*—The plat was opened on the east side of the shaft. A cross-cut was put out 20 feet east to the drive and was connected with the old No. 5 shaft. On the south side of the cross-cut a shallow stope below the level is reputed to have given payable stone as well as a patch of gold at the intersection of a cross-spur 30 feet south, where the drive turns westerly and at 15 feet meets the eastern reef referred to above. Eighty feet south of main cross-cut stopes on the eastern reef are exposed above the level for over 100 feet. The formation below the level under these stopes does not appear to have been tested. One hundred and forty feet

[1] The Maryborough Gold-field, by A. M. Howitt. Mem. Geol. Surv. Vict., No. 11, 1913.

# PYRENEES PROPTY. MINE

## REDBANK

Natural Surface

Scale of Feet

0 50 100 200

Geological Survey Office, Ballarat, August 1913.

Nos 10 & 11 Shaft

Shallow Shaft

### REFERENCE

- Slate
- Sandstone
- Dyke
- Reef stoped out

### TRANSVERSE SECTION
(510' Six From Shaft)

Dyke

250' LEVEL

Lam.d Qz

Dyke

Reef Stoped

325' LEVEL

Dyke

RISE WINZE

425' LEVEL

A B

53' W.

Lode 2½'

53' W.

54' W.

Tracks

Sill of Shaft

MAIN SHAFT

### TRANSVERSE SECTION

Lam.d Qz. Drive N.&S.

250' LEVEL

Drive N. Lam.d Qz.

Crushed Track

325' LEVEL

MAIN

Lam.d Qz. Drive N.

Quartz

425' LEVEL

Main Shaft

Nº 5 Shaft

Drive along a Graphite Pug or Slide

56'W. 40'W. 58'W. 50'W. 45'W.

Section I.

Track 55'W.

325' LEVEL

250' LEVEL

### PLAN

425' LEVEL

56'W. 45'W. 60'W. 56'W.

62'W. Spurs

DYKE 47'W.

Nº 7 Shaft

Nº 8 Shaft

Nº 9 Shaft

Spurs on Wall Pitch 37'N.

DYKE

Underhand Stopes

A Line of Section B

RISE WINZE RISE Auriferous Spur

Small Vein

Spurs Quartz 2'

65'W.

Wall Irregular

Reef 3'

45'W.

Nos 10 & 11 Shaft

Nos 12 & 13 Shaft

Sill of Shaft

MAIN PROJECTION

DYKE

Stopes on Eastern Reef

250' LEVEL

325' LEVEL

425' LEVEL

SHAFT

INTERMEDIATE LEVEL

Nº 7 Shaft

Surface

VERTICAL

Nº 8 Shaft

Nº 9 Shaft

LONGITUDINAL

Natural

Nos 10 & 11 Shaft

Western Reef

DYKE

Stopes

DYKE on

INTERMEDIATE LEVEL

WINZE

RISE

RISE

Nos 12 & 13 Shaft

south from main cross-cut, a cross-cut west for 52 feet shows a roll in the strata (Fig. 1) with

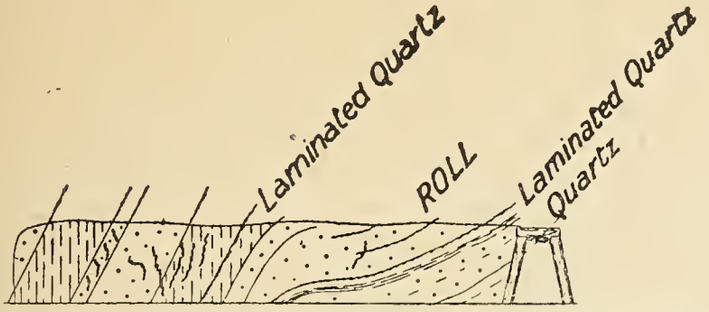


Fig. 1.—Section of Cross-cut showing Roll in Strata 150 Feet South of Shaft 250 Feet Level.
(Scale, 30 feet to 1 inch.)

a small lode following the bedding. The average dip of the eastern lode in the level and stopes is 53° W. At 310 feet south of main cross-cut a westerly cross-cut reveals the extension of the roll exposed nearer the shaft; at 30 feet from the eastern reef is the main or western reef. Stoping above this point shows the reef to have rolled on the monocline (Fig. 2), stopes up to 12 feet in width

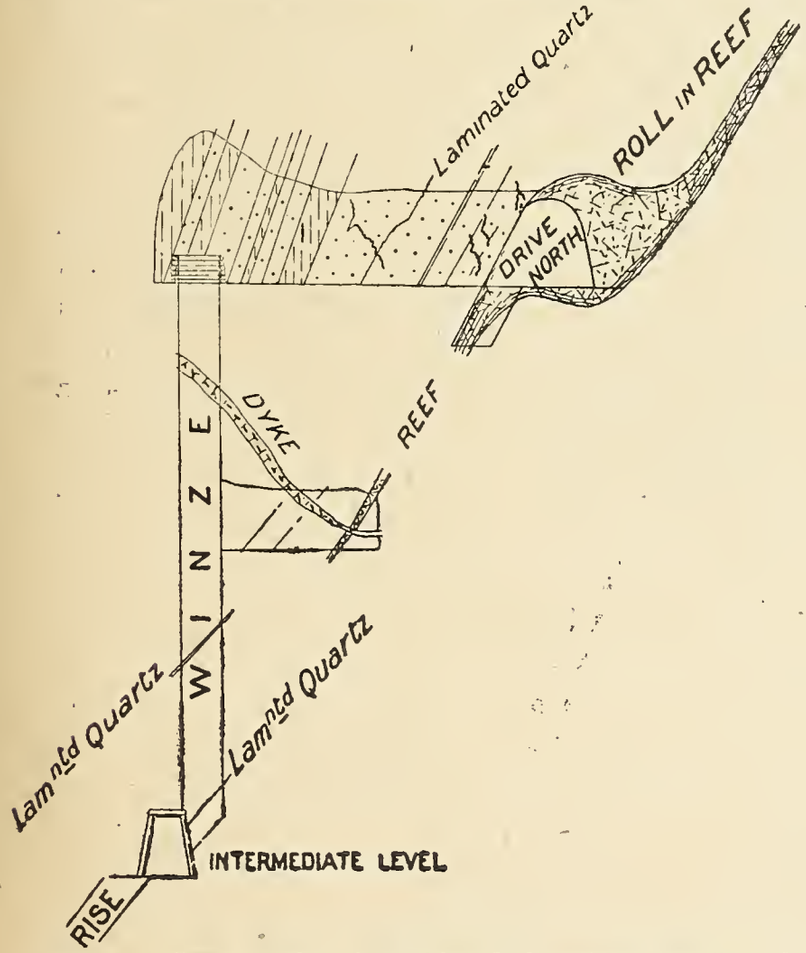


Fig. 2.—Section showing Rise below 325 Feet Level, 520 Feet South of Shaft.
(Scale, 30 feet to 1 inch.)

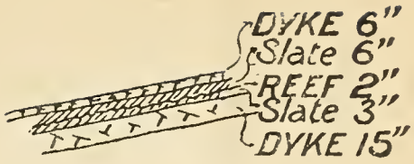


Fig. 3.

Fig. 4.

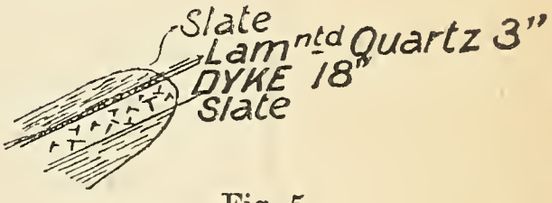


Fig. 5.

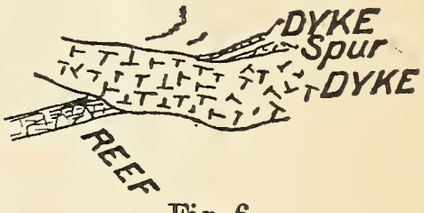


Fig. 6.

Fig. 7.

Figs. 3–7 Illustrate the Relation of the Dykes to the Reefs.
(Scale, approximate 20 feet to 1 inch.)

being visible at 10 feet to 20 feet above the drive. A diorite dyke pitching south shows in the stopes at 25 feet above the intersection of the western reef by the cross-cut. This dyke is on the floor of the drive south at 420 feet from the shaft. Stoping below the dyke extends downwards on the western reef to the level below (325 ft.) from 70 feet north of the cross-cut southwards, but little work over the dyke has been done north of the cross-cut, the reef above the dyke in this part being small. At 40 feet south from the cross-cut a rise meets the flat dyke at 16 feet above the level and from this point upwards an interlaminated series of dykes exists. These dykes form part of the horizontal dyke and in places almost entirely replace the lode (Figs. 3–7).

At times two or three parallel dykes 1in. to 18in. wide occur, separated by well laminated quartz. At other places the laminated quartz forms on one or other side of the dyke, and again elsewhere on both sides. In this respect the lode in part bears a striking resemblance to Cohen's lode, at Walhalla, but differs in this feature, that the lode here is interbedded. The dyke is undoubtedly newer than the quartz which is apparent when the reef is intersected by the horizontal dyke, fragments of laminated stone being found included therein. In the inclined dykes and reef this character is not so apparent, but nevertheless appears similar. In the back of the stopes at 100 feet (70 feet vertical) above the level the dyke is nearly 4 feet wide, with 3-in. of lode on a footwall dipping west 65°. With the dyke of such size and a small and impoverished lode further work here was not thought advisable, but an extension of the main rise for prospecting purposes should be considered, as the bulge in the dyke may contract at any time or the dyke assume a horizontal course and leave the lode-channel, when the lode may be found of workable size. It should be borne in mind, however, that the shallow workings above this part (shafts Nos. 7 and 8) do not appear to have met with profitable stone, and those to the north and the south reported better success. The south stopes at from 430 feet to 650 feet from the main shaft proved the interlaminated dyke to extend to at least 100 feet vertically above the horizontal portion, and what appears to be portion of another horizontal dyke comes in at 65 feet above the level (or 60 feet above the main dyke) at 530 feet south of the shaft. At this point a spur made from the footwall of the lode and carried some rich specimens. The back of the stopes here shows the lode much broken by the dyke. In the extreme southern end of the stopes 100 feet further south, the lode, from 6-in. to 8-in. of payable quartz, appears to be above the disturbed portion; the inclined dyke still forms the foot-wall and is 4 feet thick, dipping west at 55°. Further work at this point is contemplated and an effort should be made to hole through to Nos. 10 and 11 shafts, which lie within 30 feet north from the rise at 90 feet from the south face. About 60 feet of rising on the lode should give a sufficient height for the holing through if on the same lode channel.

With regard to the distribution of the gold, it has been found within the last two years that in stoping above the 250-ft. level a more extensive development of auriferous stone existed than was supposed from previous workings. So far as can be noticed, the shoot of gold in this part of the mine appears to be associated with the portion of the lode where the interlaminated dyke occurs, and the stoping limit appears to have been regulated by a break in the lode caused by intrusion or faulting rather than any deterioration in the quality of the stone, which up to the disturbance was of payable values for a length of 200 feet.

*No.* 2 (325-*ft.*) *level.*—At this level the plat was cut on the western side of the shaft. At a distance of 25 feet from the shaft the cross-cut intersected a reef track associated with which there was some laminated stone on which a drive southerly was put in for 70 feet. At this distance the drive swings out to the track of the western lode and, at 250 feet from the main cross-cut, there are stopes which connect to the 250-ft. level. The reef at the northern end of the stopes varied from an inch or two up to 18 in. in width. At 360 feet south of the shaft a horizontal dyke occurs on the floor of the drive parallel to that exposed in the level above and similar in appearance. This dyke pitches south and has a sinuous course horizontally. Above the dyke some very rich stone was met with. The stopes above the dyke at this level are about 300 feet long. Underhand stoping, 7 feet deep, extends between 400 feet and 500 feet from the shaft. At the latter point a roll occurs, a large mass of poor white stone with laminated payable quartz on either wall

being exposed. Beyond this point the gold values were irregular, but prospecting operations in this locality should be undertaken when funds permit. At 500 feet south of the shaft, a cross-cut was put in 30 feet west of the hanging wall of the lode, and a winze sunk to a depth of 60 feet from this cross-cut passed through the lode (which was here only a few inches wide) at 40 feet below the sill. When my first inspection was made, this winze was filled with water and no lode was reported to exist in it. This information, however, must have been available nearly two and a half years ago, and had it been disclosed it would have had a marked effect in the subsequent career of the mine. Just above the cross-cut referred to, the stopes on the roll show a width of nearly 20 feet, thereafter assuming a width of 3 feet to 4 feet when highly inclined.

*No.* 3 (425-*ft.*) *level.*—The cross-cut at this level west of the shaft passed through several tracks, including one in the plat not seen in the levels above. At 70 feet west, north and south drives were put in on what appears to be the same wall as that in the stopes at the 250-ft. level. North on this track no stone was met with, but a short cross-cut west at 100 feet from the main cross-cut passed through two better looking formations. To intersect these, the main north drive was turned west, and 200 feet from the main cross-cut it disclosed the western formation 2 ft. 6 in. wide and dipping 64° W. On this formation the level was continued for 60 feet when the stone cut out completely, only a clean slate face being exposed at the north end of the level.

South from main cross-cut for over 250 feet a track or slide along a bedding plane was followed. From this point the drive was turned to a parallel slide or pug along a graphitic wall. At 340 feet south a cross-cut west shows two parallel tracks, the western one of which is 2 in. wide ; this track appears to correspond with the western lode of the level above. At 520 feet south of the cross-cut a rise connects by a short intermediate level north to the winze from the 325-ft. level. This connexion shows that the drive south at the 425-ft. level was put in on a wall parallel to that on which the western lode exists and distant therefrom about 12 feet.

Future work at the mine depends largely on the above evidence and it is desirable that a short cross-cut be put in westerly at say 50 feet north of the connecting rise.

At present operations are being carried on at an intermediate level at the foot of the winze from the 350-ft. level. This work is useful, for although not on the western lode, short rises can be put up to the lode. At the date of the survey a short cross-cut east at 31 feet below the sill of the winze showed a well defined, highly mineralized lode 8 in. wide, cut through by a dyke 1 ft. wide, and having an easterly dip. No displacement of the lode or strata was caused by the dyke. Driving north and south on this lode would, if its quality were good, afford a suitable position for an intermediate level, being in the vicinity of the intersection of the dyke and the reef. In the upper level the richer stone was frequently met with in similar positions.

In conclusion it is apparent that although the reef is of small average size the occurrence of rolls adds considerably to the available quantity of quartz. Two distinct horizontal dykes and probably a third one occur in the stopes above the south end of 250-ft. level. The inclined dyke is only noticeable above the 250-ft. level, the lower dyke having no vertical offshoot. The extension southerly of the 250-ft. level to intersect the formation proved in No. 13 shaft is desirable. This work might be pushed on after a connexion is made with the No. 10 shaft.

Should the cross-cut recommended at the lower level prove the downward continuation of the lode, the main drive should be turned westerly at the southern end, and the lode followed.

While there is evidence of a southerly pitch on the eastern lode, the shoot of stone on the western lode does not appear to pitch rapidly, but to be rather of the nature of a nearly vertical body. The downward continuation of the shoot on the eastern lode below the 250-ft. level should be looked for by cross-cuts easterly at intervals along the 325-ft. level between 150 feet and 300 feet south of the shaft.

## APPENDIX A.

Particulars of returns from shallow levels, Pyrenees Reef, Redbank, certified by the local Mining Registrar :—

| Claim. | Ton. | Oz. dwt. gr. | Width of Reef. | Deepest Workings. | Year. |
|---|---|---|---|---|---|
| | | | ft. | ft. | |
| Prospectors .. .. .. | 387 | 950 0 0 | 2 | 140 | 1863 |
| No. 1 South .. .. .. | 280 | 528 0 0 | 2 | 140 | 1863 |
| No. 2 South .. .. .. | 373 | 846 0 0 | narrower | 150 | 1864 |
| No. 3 South .. .. .. | 219 | 396 0 0 | ,, | 150 | 1864 |
| No. 4 South .. .. .. | 312 | 1,594 0 0 | 2–3 | 160 | 1864 |
| No. 5 South .. .. .. | 774 | 2,840 0 0 | 2–3 | 175 | 1864 |
| No. 6 South .. .. .. | 65 | 77 0 0 | 2–3 | 180 | 1864 |
| Nos. 10 and 11 South .. .. | 113 | 197 0 0 | 2–3 | 150 | 1864 |
| Nos. 12 and 13 South .. .. | 397 | 377 10 0 | 2–3 | 160 | |
| No. 7 .. .. .. | .. | 1½ oz. to ton | 2–3 | 210 | |
| Nos. 8 and 9 .. .. .. | .. | .. | .. | 130 | |

Other crushings from this line, but no record as to claim, 1,704 tons for 1,617 oz. 10 dwt. 11 gr.

### Pyrenees Company.

Prior to 1902, 613 tons were crushed for 468 oz. 18 dwt., exclusive of pyrites.

## APPENDIX B.

Returns of stone treated by present company :—

| Quarter Ending. | Tons Crushed. | Total Yield. | Quantity Treated to Date. | Gold Yield to Date. |
|---|---|---|---|---|
| | | Oz. dwt. | Tons. | Oz. dwt. |
| 30th June, 1909 .. .. | 155 | 249 16 | .. | .. |
| 30th September, 1909 .. .. | 280 | 321 14 | 335 | 393 8 |
| 31st December, 1909 .. .. | 115 | 98 0 | 450 | 457 6 |
| 31st March, 1910 .. .. | 250 | 166 4 | 700 | 642 10 |
| 30th June, 1910 .. .. | 316 | 189 0 | 1010 | 830 10 |
| 30th September, 1910 .. .. | 603 | 309 3 | 1613 | 1197 13 |
| 31st December, 1910 .. .. | 613 | 469 5 | 2226 | 1619 18 |
| 31st March, 1911 .. .. | 1169 | 841 0 | 5467 | 2565 0 |
| 30th June, 1911 .. .. | 828 | 797 0 | 3863 | 3020 12 |
| 30th September, 1911 .. .. | 1439 | 522 9 | 5302 | 3492 0 |
| 31st December, 1911 .. .. | 629 | 466 9 | 5931 | 3936 10 |
| 31st March, 1912 .. .. | 704 | 442 13 | 6636 | 4420 3 |
| 30th June, 1912 .. .. | 1194 | 541 8 | 7830 | 4961 11 |
| 30th September, 1912 .. .. | 863 | 414 0 | 8693 | 5375 11 |
| 31st December, 1912 .. .. | 299 | 279 4 | 8992 | 5833 0 |
| 31st March, 1913 .. .. | .. | .. | 8992 | 5833 0 |

Since my last visit in July, 1913, operations have been conducted on the lines laid down in my previous report, and a definite policy has been carried out with encouraging results. At the 425-ft. level the south drive was turned westerly and the main line of lode worked in the upper levels was located, proving that the drive southerly for a distance of 600 feet from the cross-cut was along the eastern track. Shortly after the main or western track had been cut, a laminated lode came in ; this lode, consisting of 18 in. to 20 in. of payable quartz, was followed from 660 feet from the cross-cut to 880 feet—a length of 220 feet. After a blank of 6 feet the drive followed another make of quartz 60 feet in length and 9 inches to 1 foot wide, carrying galena and zinc blende. It contained free gold, but not sufficient to make it payable. This was followed by another blank of 20 feet and then a fresh make of highly mineralized gold-bearing quartz which widened in 20 feet to 3 feet but tapered out in the next 20 feet, leaving a track in the face at 1,013 feet from the cross-cut. Further prospecting by means of driving this level is warranted. In the intermediate workings above this level a length of 70 feet of payable stone is opened up, the reef ranging from 1 foot to 5 feet wide on a roll. This roll is apparently dying out towards the south, being less pronounced in this direction. A connecting winze known as Perry's shows a reef from 12 inches to 24 inches wide to the lower level, while a rise on the reef connects with the 325-ft. level. At the 250-ft. level the south drive has been extended on the lode track which is much broken by a dyke, but in the south face a body of highly mineralized quartz 5 feet thick is worth driving on for at least 100 feet. Future operations should embrace development of the quartz already exposed —a total of nearly 300 feet being opened for stoping. The extension of the 250-ft. and 425-ft. levels further south is advisable, the former on the stone exposed, the latter on the track in the face. A rise above the 425-ft. level on the most southerly make of stone 985 feet from the cross-cut should be taken in hand at once, as a means of ventilating the whole of the workings can easily be secured if the quartz continues upwards. A short cross-cut west at 500 feet south in the 425-ft. level, also one east at 250 feet south on the 325-ft. level, are also desirable.

The operations carried out since my last visit have revealed the downward continuation of the lode, which is well defined and regular, and away from the influence of the diorite. As work proceeds a scheme for the working of the reef at a lower level can be formulated. It is therefore advisable to build up a reserve fund which should be forthcoming from the treatment of the several thousand tons of quartz now in sight.

[15.9.14.]

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## NOTES ON BEALIBA.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

Bealiba is 137¾ miles from Melbourne, on the Mildura railway line, and 688 feet above sea-level. The country rock consists principally of Ordovician strata, apparently well down in the series, like the Lancefield and Bendigo beds. Granite is also present.

Quartz reefs have been worked in several localities, and some of them are reported to have yielded well. Two miles north-east from Bealiba the Welcome reef has been worked for a length of about 500 feet, and to a depth of 400 feet. At the bottom level a cross-cut was driven 150 feet east, and a reef was cut, but such an inflow of water ensued that the shaft was abandoned.

At the surface the reef is split into two branches, each about 2 feet thick. The strike of the western branch is N. 20° W., and the dip about vertical. The country rock consists of yellow and grey slate and sandstone, and the soil is red in colour. A dyke, apparently a lamprophyre, occurs in connexion with this reef, but it is much decomposed. Payable stone is said to have been followed to the bottom of the shaft.

About 1½ miles from Bealiba, on the railway line to Dunolly, a group of auriferous reefs has been worked, including the George, Post Office, Break o' Day, Cairns and Cross reefs. They are reputed to have been payable, but were worked only to water-level, less than 100 feet from the surface. The gold is said to be exceedingly fine and difficult to save, except by cyanide.

At Moonlight, lying about 1½ miles in a south-western direction from Bealiba, the rocks are sandstones metamorphosed through their proximity to granite. They strike W. 10° N. On the north side of the gully a large bulge of quartz, 10 feet to 12 feet across, occurs in the reef, which strikes about north and south. Moonlight Gully was worked for alluvial gold down to Puzzle Flat, and specimens of quartz and gold were numerous. These were, no doubt, derived from Moonlight reef, which crosses the head of the gully and runs for a considerable distance, but has only been worked in a small way. Billy Nutt's reef, which is nearer Bealiba, strikes N. 20° E. and dips 85° E. It has been worked for a length of 200 yards, and to a depth of 50 feet, with payable results.

Alluvial mining has been carried on more extensively than quartz mining at Bealiba. The principal lead starts about due west of Kingower, and crosses the main road from Bealiba to Dunolly at 1½ miles from the former town ; at Bald Hill Flat the lead sweeps round south of Bealiba and runs south-westerly to Puzzle Flat, and on to Liverpool Flat. This lead is of Older Pliocene age, and is a high-level lead, running through a series of hills until Puzzle Flat is reached. Various branch leads run into the main lead. Where the old lead has been cut through by recent gullies, gold should be found, but search for it has been hindered by the quantity of water met with in these flat gullies.

At Puzzle Flat a striking feature is the large size and well-rounded character of the quartz boulders in the washdirt, some up to 3 cwt., some still heavier. This lead has a length of 13 or 14 miles, hence the well-rounded condition of the boulders and pebbles. Liverpool Flat is about half a mile below Puzzle Flat, and much of the lead between the two places is unworked, the reason, it is stated, being the quantity of water to be dealt with. At Liverpool Flat several holes have been bottomed, and the washdirt taken out at a profit. The slimes from the washdirt were worked over by Chinamen two or three times, and still they are profitable to treat by cyanide. This indicates the extremely fine subdivision of the gold. Gold occurs in the headings as high as 10 feet above bedrock. The conditions that exist at this lower end of the lead are such that the headings, sands, silts, clays (pug), &c., that occur, covering up the washdirt, and also the pipeclay bottom, are well worth careful trials to ascertain whether there is sufficient fine gold present to pay for cyaniding. There are great quantities of the finer materials to be dealt with, if only sufficient fine gold could be proved to exist in them.

Beyond Liverpool Flat the lead appears to expand, and in Cahill's paddock the workings cease. One of these shafts, which bottomed at 113 feet deep, is said to have yielded 3 dwt. of gold to the load, but the water was too strong for the appliances used.

There is considerable doubt as to the course taken by the lead between this and the Avoca River, and some boring might be done with a hand-drill to settle the point. It is quite possible, and even probable, that there is an absence of any well-defined channel in this locality, and if such is the case a few bores should prove it.

[23.1.11.]

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## WOLFRAM AT LINTONS.

*By W. Baragwanath, Senior Field Geologist.*

The existence of wolfram in the locality of Lintons is recorded as far back as 1869, when a prospector—Smith Tibbett—formed a co-operative party and secured a lease of 100 acres. Samples of ore submitted by him to the Mining Department in June, 1869—(*Ballarat Star*, 29.6.69)—gave quartz, brown tourmaline, wolfram, iron and copper pyrites, manganese, molybdenite, carbonate and oxide of copper, carbonate and sulphide of bismuth, native bismuth, gold and silver. These samples came from the three reefs at present being exploited.

In 1891 Tibbett, junior, returned to the locality and reopened a shaft sunk by the earlier party, and again disclosed the wolfram, which had by this time increased in value from £6 to £30 per ton. Endeavours to induce a Melbourne company to develop the ground proving futile, work was stopped and nothing further was attempted till a couple of months ago, when, on being shown some samples of wolfram-bearing quartz, I suggested to the prospectors the desirability of further search for wolfram and other minerals.

The locality lies about midway between Lintons and Skipton, and north of the connecting road, at a point formerly known as Spring Vale. The reefs outcrop on the summit of a range of metamorphic rocks with granite occupying the flat country to the south, and probably also underlying newer gravels at no great distance to the north. For metamorphic rocks the strata are remarkably soft, and consist chiefly of slaty beds. Quartz reefs in the metamorphic zone are common, and two of these are proved to contain the above-mentioned minerals. Considering the number of reefs and the length of time which has elapsed since the little prospecting was done, it was remarkable that the area should have been neglected, but probably the fact that the land has been alienated has had its effect.

At the date of this examination, work was being, or had been, carried on at two points about 50 chains apart. The most easterly outcrop, Quinn's Lease, showed a large lode formation striking east of north and underlying east. Wolfram occurs on the eastern or hanging wall. Two samples were submitted from this spot in June and July, 1912, and gave the following results :—

| Assay No. | Tungstic Acid ($WO_3$). |
|---|---|
| | per cent. |
| 368 | 2·53 |
| 386 | 2·54 |

For about 100 yards north of the main outcrop samples of wolfram bearing quartz occur on the surface. A northern cut of about 8 feet deep shows a vein of wolfram-bearing quartz up to 9 inches in width. From this cut and

the southern one a trial crushing of roughly-picked material is being tested at the Ballarat School of Mines. Along this line of reef the wolfram occurs in fine crystals, forming veins up to an inch in width, with quartz interspersed along the laminations ; the remaining portion of the reef where large is devoid of wolfram, but samples assayed for gold gave the following results :—

| Assay No. | Gold per ton. | Silver per ton. |
|---|---|---|
| | oz. dwt. gr. | oz. dwt. gr. |
| 366 | 0 1 19 | 0 1 7 |
| 385 | 0 3 22 | 0 1 23 |

On the western outcrop (Bass & Watson's), an old shaft, sunk by Tibbett in 1869, is recorded by Mr. R. M. Sergeant in the *Ballarat Star* of the 29th June, 1869, as having in it a lode 5 feet wide highly charged with wolfram, some crystals of black oxide of manganese, and stains of copper. This shaft has now caved in, but the prospectors made a surface cut into the reef, and revealed the hanging wall of a lode over 10 feet in width carrying wolfram for a width of 2 feet. In this reef, the wolfram occurs in large crystals of 4 oz. and 5 oz. weight, also as loose pieces in the clay adjacent. At the date of inspection, this cut was 5 feet deep, but the prospectors purpose sinking a new shaft to cut through the lode at a depth to ascertain its value.

Wolfram exists in apparently payable quantity in both cases, but the conditions are dissimilar in that the crystals of wolfram from the western reef are large, while in the eastern reef they are usually small.

Fine specks of free gold occur with the wolfram, and assays of samples gave—

| Assay No. | Gold per ton. | Tungstic Acid ($WO_3$). |
|---|---|---|
| | oz. dwt. gr. | per cent. |
| 385 | 0 3 22 | 0·44 |
| 387 | 0 7 20 | 0·51 |
| 368 | 0 3 22 | 2·53 |

Metallic bismuth and oxide, carbonate, and sulphide of bismuth occur in the reefs usually adjacent to, but not in association with, the wolfram. Scheelite in crystals can also be observed, as well as tungstic ochre, with the wolfram in surface specimens.

Copper pyrites is recorded, but none was observed by me, though covellite was visible in cavities from which pyrite has decomposed. There is little doubt that the area is one which merits prospecting, and if the various applicants for leases fulfil the labour conditions necessary to hold their areas, good results are likely to accrue. A sample shown to me while visiting the area came from a mile east of the easterly reef, and contained a crystal of wolfram, while a sample in the Ballarat School of Mines Museum is recorded from Flagstaff Hill, about 1½ miles east of the most easterly point, which agrees in position with the reef known as the Superb, exploited by the Superb Copper Mining Syndicate in 1869.

An analysis, made in 1869 by Abel, giving manganese protoxide 58·50 per cent., is interesting as coming from the locality.

# THE PRINCE OF WALES GOLD MINE, WEHLA.

*By A. M. Howitt, Field Geologist.*

The present report on the deeper levels of the Prince of Wales Gold Mine, Wehla, is an appendix to a former report which dealt with the main workings from the surface to a depth of 250 feet.[1]

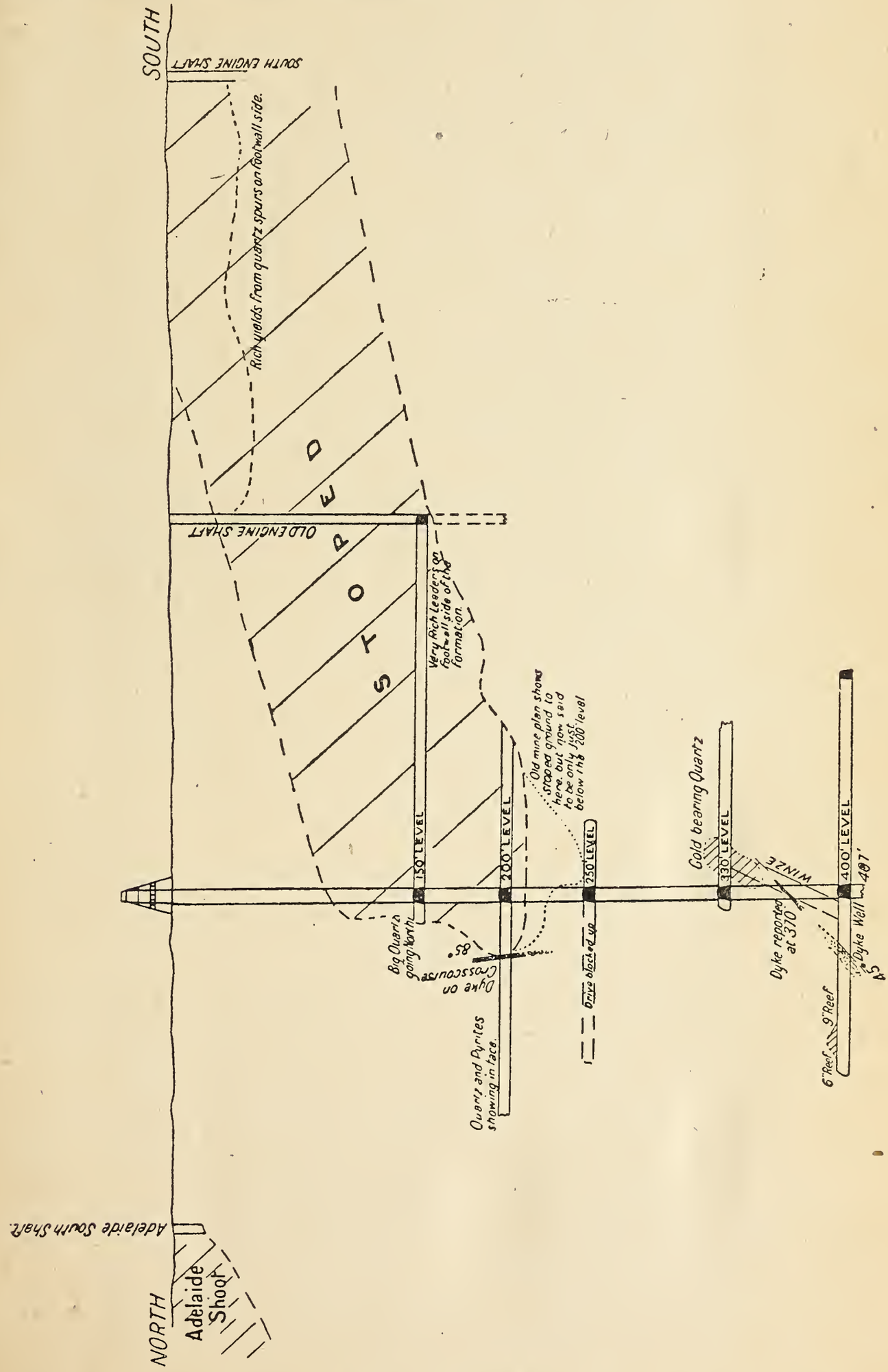


Fig. 8.—Longitudinal Section, Prince of Wales Mine. Scale, 120 feet to 1 inch.

[1] The Prince of Wales Mine, Wehla, by A. M. Howitt, Rec. Geol. Surv. Vict. Vol. III. Pt. 2, p. 134.

At that time the south drive at the 250-ft. level was in 25 feet from the cross-cut, and the face showed a reef-formation of mineralized and laminated quartz with footwall spurs, making a width of 4 feet in all. This reef dipped 77° W. in country dipping 70° W. Shortly after my inspection the drive was discontinued at 38 feet, as prospects did not improve.

## Deeper Levels.

After work was suspended at the 250-ft level, the main shaft was re-timbered to the 330-ft. level and further sunk to a depth of 407 feet (including the well).

*The 330-ft. level.*—At the 330-ft. level the old company had cross-cut 28 feet to the reef, which was 2 feet wide and laminated on the hanging wall side. The reef at this level dips 80° W. and the beds 80° E. A drive extends 110 feet south, and has proved a fairly strong reef-channel contained in walls sometimes of slate, but mostly of sandstone, the hanging wall always being well defined and regular, but the foot-wall more or less irregular. The old company started to sink a winze south of the cross-cut, and this was continued by the present company, who followed a shoot of gold-bearing quartz on the hanging wall. From this a crushing of 1 ton yielded 17 dwt. 20 gr. of gold. This block of quartz was taken out for a length of 14 feet. It gave out at 20 feet in the winze, but above the winze the reef shows strongly and is about 2 feet wide, 10 inches of which on the hanging wall is reported to carry payable gold. It was being risen on at the time of my inspection. The intention of the present management is to have further crushings from this level on the erection of the battery, which is now in hand.

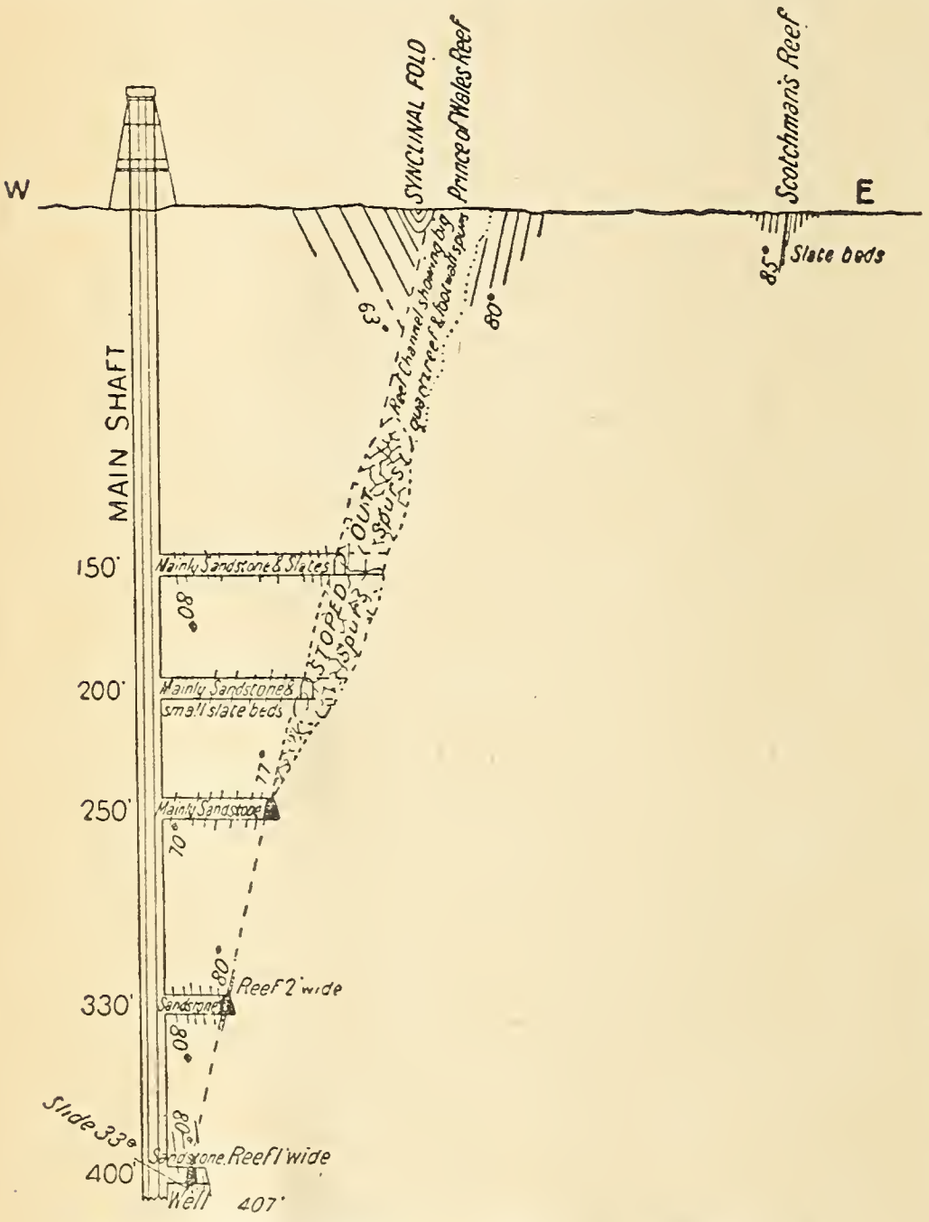


Fig. 9.—Transverse Section. Scale, 120 feet to 1 inch.

The gold-bearing quartz may continue upwards to the 250-ft. level, and, if so, it would be carried on the pitch to the south of the south face at that level.

*The 400-ft. level.*—At the 400-ft. level the cross-cut east intersected the reef at 11 feet from the shaft, and proved 1 foot of quartz carrying pyrites. This quartz dips 80° W. across beds dipping 80° E. A small slide carrying flucan and crushed rock, and dipping 33° E., went underfoot in the cross-cut just before reaching the reef. This cross-cut was extended for a further 7 feet past the reef and exposed hard sandstone beds.

North from the cross-cut a level has been driven 105 feet on the reef, which dips 80° W., cutting beds dipping 80° E. The quartz is from 6 inches to 1 foot in width, and carries pyrites, and as in the upper level has a well-defined hanging wall.

At 90 feet north of the cross-cut prospects of gold were obtained in a 9-in. vein of quartz, and this was risen on for 6 feet, but did not improve.

At 32 feet north of the cross-cut a dyke rock dipping 45° N.E. was cut, and this may be continuous with the reported dyke cut at 370 feet in the shaft, which would pass just below the point at which the quartz block cut out in the winze.

A rise north of the cross-cut connects with the winze from the 330-ft. level.

A level south from the cross-cut has been driven for 128 feet, and a cross-cut from its south end extends east 28 feet, exposing hard sandstone and quartzite beds with some narrow beds of slate dipping 80° E. and carrying some quartz spurs. Along this south level the reef seems somewhat disturbed, and makes a roll to the east, the beds also dipping east. The strata are sandstones and quartzites, with narrow slate beds all dipping to the east at an angle of 80°; in the south cross-cut the slates are slightly more frequent. This points to more slates occurring to the east, as might be expected.

### General Aspect.

The developments since the last report show that the beds passed through are hard sandstones and quartzites with narrow beds of slate, and, therefore, the conditions have not been favorable to the occurrence of large reef formations and spurs of quartz similar to those worked above the 200-ft. level to the surface, where the slate beds predominated and the reef channel was wide and associated with large footwall spurs of quartz.

In my opinion, the auriferous quartz at the 330-ft. level should be further prospected by following the stone downwards on its northern pitch, besides following it above the winze, which is the policy of the present management.

Further driving north at the 400-ft. level may cut other blocks of quartz on the pitch north from the one now being worked at the 330-ft. level.

As the series of western-dipping slates to the east, which accompany Scotchman's reef, has not yet been met with, further sinking is advisable, as the larger formations with quartz spurs cannot be expected until this second series of favorable slate is met with as it folds under on the syncline.

[13.3.11.]

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## PATTEN'S MINE, BROWN'S REEF, EVANSFORD.

*By H. S. Whitelaw, Field Geologist.*

Brown's reef, about 1½ miles north of Evansford, is evidently a leg on the western side of an anticline striking nearly north and south. It was discovered about forty years ago, and was then worked with payable results for a length of about 60 feet and to a depth of about 30 feet. Later, a party of local farmers took it on tribute and worked it down to about 40 feet for yields which returned about £1 per week per man. About two years ago the present holders obtained a lease along it and sank a vertical shaft to a depth of about 95 feet at the end of the old workings, with which, for ventilation purposes, a connexion was effected at a depth of about 30 feet. The reef at about 84 feet from the surface passed through the shaft. At

that depth a level was driven north for about 70 feet. From the shaft to 25 feet north, the reef was stoped to a height of from 10 feet to 20 feet above the level, the returns proving payable. As the reef has a northerly pitch, two winzes were sunk on it, one at 30 feet north of the shaft, the other at the end of the level. In the first, the shoot was picked up at a depth of 25 feet. From the bottom of this winze, according to the manager, an inclined drive (which is now inaccessible) follows the reef on its pitch to a point between 90 and 100 feet from the shaft. Three crushings were taken from the winze and drive, the first yielding 3 dwt. per ton, the next 6 dwt. 6 gr. per ton, and the last 14½ dwt. per ton. There is now stacked on the surface about 12 tons of quartz, which, it is estimated, will yield 1 oz. per ton.

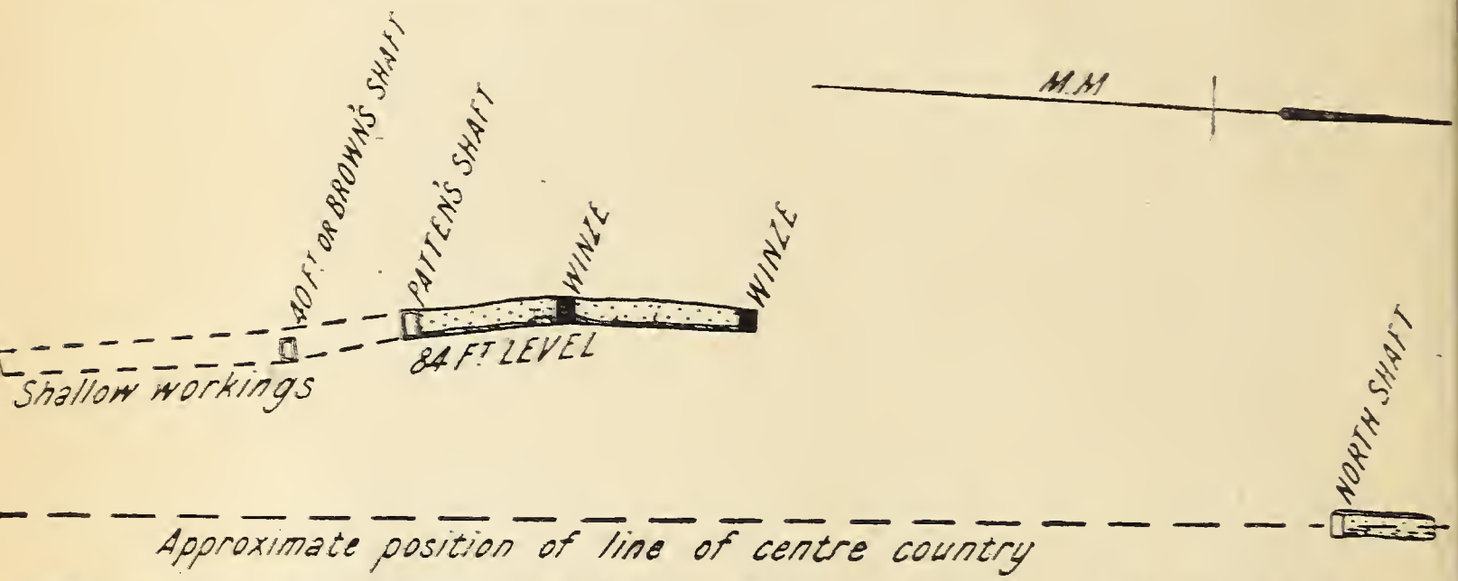


Fig. 10.—Plan showing Position of Anticline in Relation to Workings. Scale, 80 feet to 1 inch.

The reef, which resembles the west leg of a saddle reef, contains galena, black jack, iron pyrites, and arsenical pyrites (a high percentage of this), and is bedded in slightly altered sandstone, which, between the shaft and No. 1

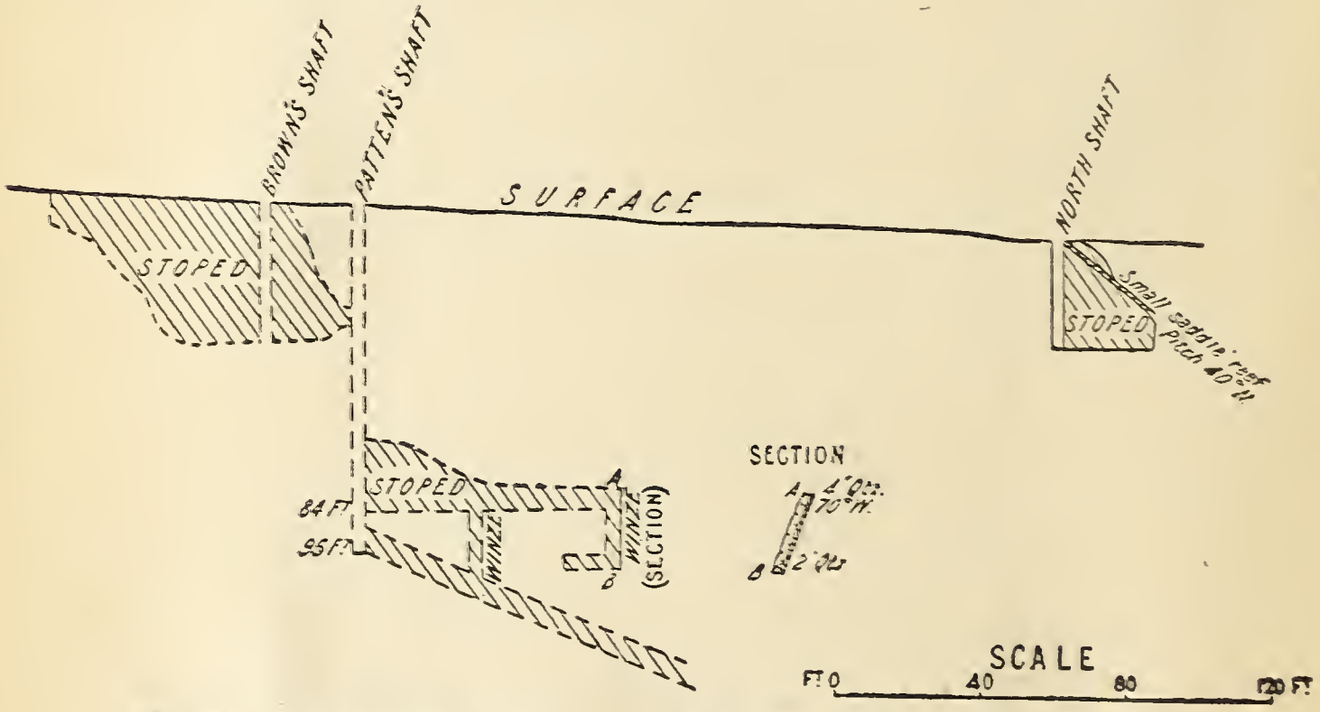


Fig. 11.—Longitudinal Section showing Stopes. Scale, 80 feet to 1 inch.

winze, strikes N. 10° W., and between No. 1 and No. 2 winze strikes N. 2° E. The average dip is 70° W. The reef varies in width between 2 inches and 14 feet—the widest part being in the inclined drive immediately north of No. 1 winze.

Working becoming irksome in the inclined drive, the mine was temporarily abandoned, and a shaft started in quartz which outcropped at 190 feet north of the main shaft. A depth of 28 feet has been attained here, and from the bottom a drive has been put in 25 feet north on the west leg of a small saddle reef pitching 40° N. From this reef (cap and leg) 14 tons have been crushed for a yield of 8½ dwt. per ton. The axial strike of the anticline containing this reef is about N. 3° W., the anticline being about 40 feet east of the main shaft.

Along the strike northward from Patten's shaft, auriferous quartz has been found at intervals for over a mile, and several gullies, below where they are crossed by the line of strike, have been worked for gold. Bedrock exposures not being continuous, it is not easy to trace the line in either direction.

To date operations by the present holders have proved just about payable, notwithstanding that the quartz for crushing has to be carted to the Government battery at Amherst, 14 miles distant, and, as far as can be judged from the open workings, and the information supplied with regard to the closed portion of the mine, it seems advisable to continue prospecting the western reef, and also to sink in the anticline in search of other saddle reefs which experience shows are likely to recur with depth.

[22.10.12.]

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## THE YANKEE DOODLE REEF, GOLDSBOROUGH.

*By A. M. Howitt, Field Geologist.*

The exact locality of the Yankee Doodle Reef is on the north side of Nuggety Gully, and 300 yards east of Whittaker's allotment 19, parish of Painswick. It is about one mile south of the Queen's Birthday mine, and is on the same line of reef.

The shallower workings were examined in 1909, and a report on them was published[1].

Since the inspection in 1909, Skane and party have sunk a vertical whip shaft to a depth of 150 feet. This shaft is only 23 feet at N. 5° E. from the old 40-ft. north shaft. It has levels at 50 ft., 100 ft., and 150 ft.

At the 50-ft. level the black slates referred to in the previous report were cut at the shaft and driven on 13 feet north and 37 feet south. In these black slates decomposed iron pyrites is abundant. From the end of the south drive a short cross-cut west is connected by a rise to the old 40-ft. shaft, and from which the best assays of black slates came. Here the strike is N. 20° W., and the dip 75° E. A section of this south end shows three narrow bedded quartz veins among the slates.

From the 50 ft. level a parcel of 2 tons of black slate and quartz veins has recently been taken out and sent to the Ballarat School of Mines for treatment.

At the 100-ft. level a cross-cut west for 70 feet shows at 3 feet a 3-inch quartz vein and about 6 inches of a graphitic vein cutting the strata at a small angle; at 21 feet, a 3-inch bedded quartz vein separating the softer black slates from a 10 ft. series of hard black slate; from 31 feet to 70 feet, light-coloured slate beds, only slightly mineralized and showing no quartz veins. The east cross-cut was mullocked up and inaccessible, but from information supplied it appears that alternate beds of black and grey slate occur for a distance of 14 feet, followed by 16 feet of light-coloured beds with quartz veins throughout. The footwall of this spurry formation is sandstone, and its dip is about 75° W. The length of the cross-cut is 32 feet.

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[1] Auriferous Slates, Goldsborough, near Dunolly, by A. M. Howitt. Rec. Geo. Surv. Vic., Vol. III., Part 2, p. 139.

The 150-ft. level could not be examined, as it had been closed up for some time and contained bad air. The information supplied, however, was confirmed by Inspector Mitchell, who had inspected the bottom level. The black graphitic vein was 2 feet west of the cross-cut, in the shaft, and nearly vertical.

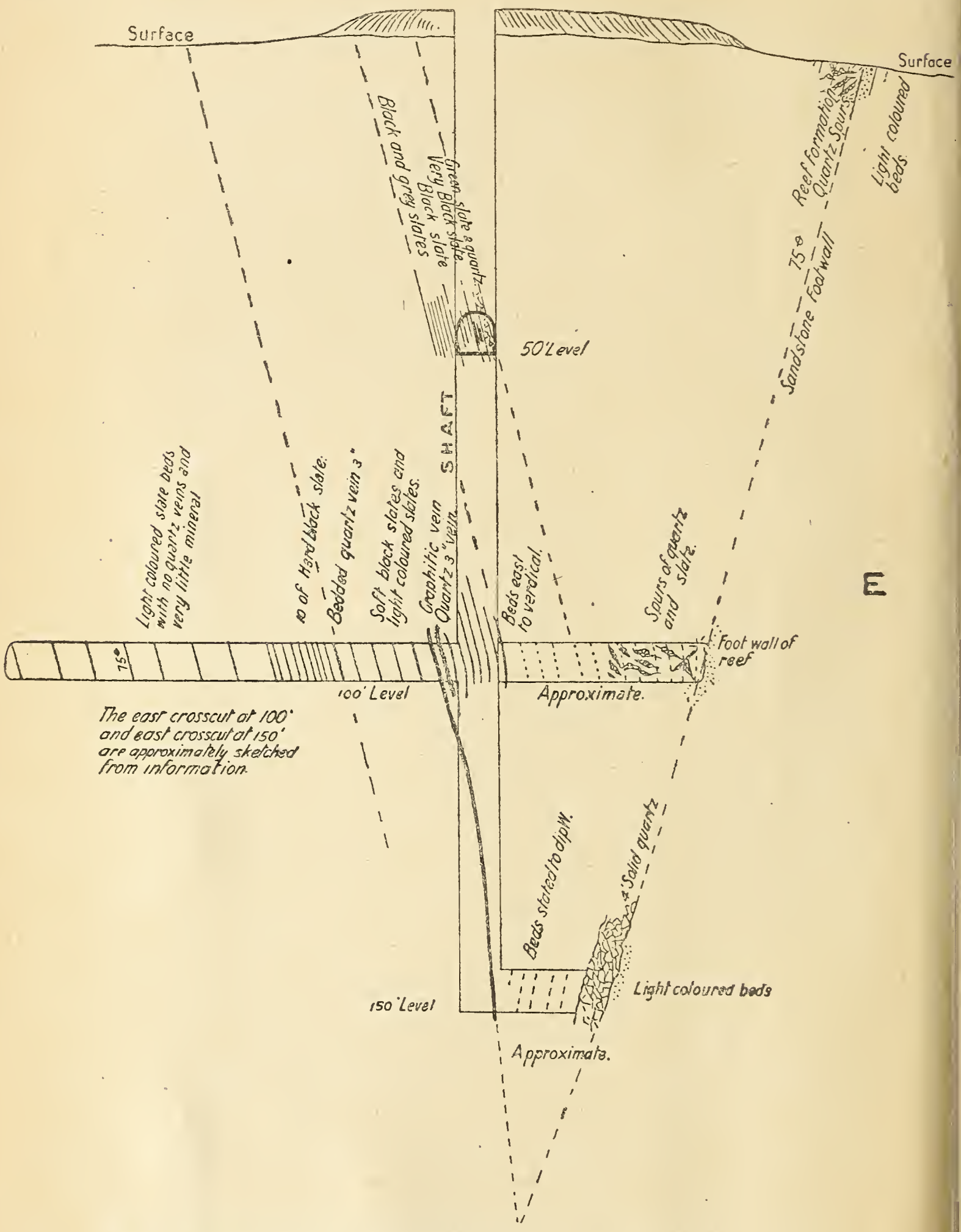


Fig. 12.—Transverse Section at Whip Shaft. Scale, 30 feet to 1 inch.

The 150-ft. level east cross-cut was driven 10 feet in west-dipping slate beds, when a strong body of solid quartz of favorable appearance was cut. A drive north of 36 feet exposed this solid stone for a width of 4 ft.

6 in., but pinching north and south to small quartz tracks on the footwall. In length this large quartz reef is over 50 feet, and prospects of about 2 dwt. of gold per ton could be obtained throughout. The south drive is 68 feet in length, with a 5-ft. cross-cut west exposing the graphitic vein in the face. As the transverse section (Fig. 12.) shows, the intersection of the black slate series and the main reef formation has not been passed through ; but since the series is of the indicator class, this intersection should be well prospected. This could be done by sinking about 30 feet and driving north and south.

The reef is on the Queen's Birthday line ; the black slate series is in itself promising, and is situated near the source of the alluvial gold in Nuggety Gully a little to the south. Further work is consequently fully warranted.

[16.9.12.]

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## AURIFEROUS AREAS NEAR TALBOT.

*By H. S. Whitelaw, Field Geologist.*

I have inspected certain auriferous areas near Talbot where, in the opinion of the members of the Talbot Prospecting and Progressive Association, there are indications which give good ground for the belief that deeper quartz mining will prove successful. The localities visited were the Southern Cross, Blucher's, and Sarah Bernhardt reefs to the north of the township, the Tunnel reef to the west, and Granite Hill to the south-west.

### The Southern Cross and Blucher's Reefs.

These reefs, the prospected portions of which lie between 2 and 3 miles north from the township, are parallel, less than 100 feet apart, and at the surface strike about N. 12° W., and dip about 70° westerly with the country. Mr. Ross, a farmer and miner who lives near by, and Mr. Allen, proprietor of the Talbot *Leader*, stated that the reefs have been worked with payable results to an average depth of about 50 feet for a length of about half-a-mile north from the Talbot-Maryborough road, near where it crosses Back Creek. The deepest shaft here (the Southern Cross, on the northern end of the workings) is, according to Mr. Ross, about 200 feet deep. From it the reefs were remuneratively worked by the original holders to water-level at 116 feet. At about this depth Blucher's reef is 78 feet east of the shaft. The mine, it is said, was paying its way below water-level, when an employé named Boyd was accidentally killed in the workings. During the inquiry into the cause of his death operations ceased. They were not resumed until Ross and party re-opened the mine and took several crushings, which yielded ½ oz. of gold to the ton, from the 200-ft. level. This average was not long maintained. The battery having been removed from the locality, the mine was again closed, and has remained so ever since. Northward from this mine is the Madame Patti shaft, from which, Mr. Ross states, four men in six weeks won gold which sold for £3,200.

### Sarah Bernhardt (John Bull) Reef.

A few chains east of Blucher's line is the Sarah Bernhardt or John Bull reef, which has been worked over about the same length as Blucher's. According to Mr. Thomas, who worked on the reef, the richest yields came from a depth of 40 feet, and he considers the length of the workings to be the length of a horizontal shoot, which was richer in places where flat makes or spurs branched westward from the main reef. Mr. Ross states that the shoots of payable quartz were vertical. Mr. Allen, whose calling necessitated his

visiting this locality at regular periods, mentions that 26 years ago there were twenty miners at work on this portion of the field, and that for some years previous to the suspension of operations the net income from his interests in the mines was over £400 per annum. He expresses the opinion that several of the mines would now be working and paying but for the fact that the owners of two, prior to the disposal of them, "salted" the faces. This, he adds, was at about the time of the exhaustion of the first shoot, when most of the mines were languishing and in need of capital to sink and prospect below water-level. The effect of the discovery of the salting was that capital was withheld, and the mines were forced to close. Excepting that occasional small crushings have been taken from various parts of the old stopes, no work has been done since.

Little can now be seen of the structure of the reefs, but from the statements of Messrs. Ross and Thomas it would appear that they make on blocks or bulges of "buck" quartz which are connected by narrow strips laminated with green—known as velvety—slate. The narrow portions have proved the richer and more consistent producers of gold, a fair percentage of which was contained in the slate itself.

At the south end of the workings on these reefs several large nuggets, known as Munro's find, have been found in Nuggety Gully, two or three chains above where it crosses the Maryborough road. The heaviest, Mr. Ross states, weighed 43 ounces. The gully is only a few chains in length, and has been worked to where it junctions with Back Creek in Mr. Ross' property. The last machine of wash puddled from the gully contained 15 ounces of gold.

The matrix of this gold would appear to be the above-mentioned reefs, but it is said that the appearance and quality of the alluvial gold were quite different to those of the reef gold. It is possible, however, that the source was an indicator or a dyke. Indicators, it is said, have been found in other parts of the field, and may exist here. A dyke crosses the gully near where the largest nugget was found. It has been prospected unsuccessfully for gold.

### Tunnel Hill Reef.

About 1 mile west of the township is the Tunnel Hill reef. It has been worked over half a mile in length in an open cut, a tunnel, and shallow shafts, the deepest of which is said to be 85 feet. It is 45 feet thick where exposed in the tunnel, which was driven, so it is said, in 1861. It is formed on a slide striking about N. 12° W., and dipping 65° easterly. The quartz as seen here is fractured and iron-stained, and contains pieces of slate and dabs of white clay, around and in which, Mr. Gane informs me, most of the gold is generally found. Very little work has been done from the tunnel. A level on the wall or slide—which is in the centre of the reef—has been driven about 20 feet south. From the end of this there is a drive 20 feet long, and then a cut 7 feet north and south. The quartz from the north and south drives yielded 6 dwt. of gold per ton, and that from the west drive 4½ dwt. per ton. Two samples of the resultant sand, Mr. Gane states, were treated by the Mines Department, and assayed 4 dwt. and 5 dwt. per ton.

To the south of the tunnel there are several shafts on the reef, and the bulk of the stone drawn from them is said to have been more than payable. The last of the outcrop in this direction is seen in an open cut about 300 feet from the tunnel. Here the reef is spurry, and has been worked for over 100 feet in length. Results of the crushings, which residents state were often rich, were contained in the Talbot *Leader*, the files of which, unfortunately, were burned when the printing office was destroyed by fire.

Northward from the tunnel, on each side of the spur along which the reef runs, the surface has been worked for gold, the alluvial on the eastern side, in Victoria Gully, being particularly rich. The material in this gully is now being cyanided.

### Granite Hill.

Granite Hill is a conspicuous knoll about 4 miles south-west of Talbot. It is composed of a lenticular dyke of syenite, medium-grained in texture, and varying from pink to grey in colour. It outcrops over a length of about half a mile, and in the central portion is about 180 feet in width. It withstands weathering better than the surrounding Ordovician slates and sandstones (which it is intrusive into and has slightly metamorphosed along the contact), and decomposes into a richer and more friable soil. The fresh rock would form a handsome and probably durable monumental stone. At the Talbot *Leader* office is a small piece which has been dressed and polished. It evidently had been gathered from the surface, and, though of good colour and polish, a slight decomposition of the felspars detracts somewhat from its appearance. I was informed that about 25 years ago a cube of about 4 cwt. was obtained from below the surface of the central portion of the hill and sent to a London Exhibition, and that later it was exhibited in Melbourne and attracted attention. The most interesting point about the mass is that at the southern end of it alluvial gold in nuggety form has been found in a gully on the western side and traced to the contact of the slates and dyke. The suggestion is that the gold has been derived from the syenite or from quartz veins in association with it. Several holes have been sunk in the slates and sandstones near the contact without discovering auriferous quartz, but there is no sign that the dyke has been tested. Mr. Baragwanath informs me that there are two quartz porphyry dykes parallel to and near this dyke. As they were not known to the members of the Prospecting Association who accompanied me they were not searched for.

In driving through the district, my attention was drawn to many other points of interest, to which, as the Talbot belt of auriferous country is some 4 miles wide by 10 miles long, I was able in the short time at my disposal to give only a passing glance. Sufficient, however, was seen during the visit to convince me that it is owing to a lamentable lack of enterprise on the part of the inhabitants that Talbot now comes under the heading of a neglected goldfield. The surrounding country has been remarkably rich in alluvial gold, the source of which is the numerous quartz reefs in the belt of country running through the township; and although in the case of some of the existing leads which may have derived their contents from the denudation of still older leads, the position of the source of the gold cannot be determined. There are many untried places in the district, above the level of the leads, where it seems certain that the matrix of the alluvial gold is the reef or dyke at the head of the gully, and it is there that prospecting should be undertaken. Generally where this has been done a shoot of gold has been discovered, as in the case of the reefs herein referred to. Below the surface shoot others may be expected to recur, but, as far as I can learn, in no instance has a second shoot been searched for. The deepest shaft, with the exception of the Churchill, near Amherst, is the Southern Cross (200 feet).

The population of Talbot is not now a mining one, and, left to itself, is not likely to become one. A few members of the Prospecting Association recognise this, and for some time have been endeavouring to attract attention to the district. The general desire seems to be to re-work the Tunnel reef. If this be decided on, to be successful it will be necessary to attack the reef at a depth below the tunnel-level. The shoot here has a northerly pitch, and from

observations made in the open cut it would appear that neither the tunnel nor Gordon's shaft is deep enough to cut it. A good deal is to be said in favour of the project, as there is also of further prospecting Blucher's and the Sarah Bernhardt reefs, and the trenching of the syenite dyke at Granite Hill, at the head of the alluvial gully. It is unlikely that much will be done with local capital, as the Prospecting Association is not financially strong enough.

[3.12.12.]

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## THE GOLDEN REEFS, DEREEL.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

Dereel, about 1,050 feet above sea level, is situated in a direction a little west of south from Ballarat, and to the Golden Reefs the distance is 22 miles. The rocks are slates and sandstones of Ordovician age, which strike N. 15° W. and are bent into anticlinal and synclinal folds. The soil is yellow.

Shafts have been sunk and a quartz reef worked to over 100 feet in depth on the Golden Reefs line. Further north and a little west of this line auriferous quartz from 1 foot to 3 feet thick has been worked to shallow depths along the outcrop. The strike of this reef is N. 17° W., and the dip is vertical ; the surrounding rocks are soft slates and sandstones. Within 3 feet of the surface gold in a rare and most interesting form occurs in compact white quartz. This is wire gold, which varies from the thickness of an ordinary pin to one-eighth of an inch in thickness, and up to 1½ inch in length. These are in perfect crystals that have grown in length, and they must have grown to their full length first of all, and then the quartz must have formed around them. Several ounces of this gold were found in quartz that would be generally considered of barren character, judged by its appearance.

The prospectors considered that the best plan to test the formation at lower depths was by tunnelling, and this has been done from the west bank of Pinchgut Creek. The tunnel is driven W. 20° S. for a total distance of 313 feet. At the mouth of the tunnel the dip is west, at 25 feet a syncline occurs, and at 60 feet is a fault that strikes about north-east, and dips 80° S.E. ; the beds between the syncline and the fault dip east. To the west of the fault the country dips west. At 150 feet the Pinchgut reef is supposed to have been cut. This reef, which was worked extensively further northward, dips 80° W., and is conformable with the country. It here consists of quartz and mullock. About 50 feet further west is another syncline. From the second syncline to the end of the tunnel quartz spurs are abundant—intersecting country that dips east. At 300 feet auriferous spurs, ranging from 3 inches to 2 feet thick, intersect the country. A level is driven 55 feet northward, and at the end the spurs show strongly, and carry rich gold. A level has also been driven southward from the tunnel for 70 feet, and the spurs show in the face. The pitch of the country is 4 ° in a northerly direction.

At 40 feet north from the tunnel in the level a chamber has been cut 12 feet wide and 20 feet high. There are four spurs in this height ranging from 6 inches to 24 inches thick, and all auriferous. They all dip at a low angle to the east. At the face in the north level the beds are vertical, and some of the small slate bands have the appearance of indicators.

Dish prospects washed from the spurs in the north end gave prospects equal to 3 or 4 oz. of gold per ton, and the last crushing from the north end gave a result of about 2 oz. per ton. A previous crushing gave 37½ oz. of gold from 20 tons of quartz. A ten-head battery is being erected on the west bank of Pinchgut Creek to treat this stone. The tunnel has to be driven still further to prospect for other channels.

There is every reason to expect that this discovery will result in more attention being paid to this tract of country, which is likely, if opened up, to become a contributor to the gold yield. There are parallel lines of reef to the east and west, and the alienation of this mineral land should not be allowed. It is at present held in 20-acre blocks.

[4.7.10.]

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## THE MATRIX REEF, McINTYRE'S, NEAR RHEOLA.

*By H. S. Whitelaw, Field Geologist.*

The Matrix reef is situated at the head of No. 1 gully in the McIntyre Ranges, about 3 miles south of Rheola.

Between the time of the discovery of the reef in 1867 by McEvoy and its acquisition by the present holders, the Matrix Reef syndicate is said to have won over £20,000 worth of gold. Besides this amount heavy deposits of specimen gold were found in No. 1, No. 2, and No. 3 gullies, all of which head from the reef, leaving no doubt as to the source of the gold supply. The finding on the east slope to No. 1 gully of nuggets weighing 810 oz., 805 oz., and 782 oz. is recorded. Above where these were found much work in the way of shallow shaft sinking and open cutting has been done on quartz veins, and several patches of extreme richness are said to have been discovered. Unfortunately these workings are now inaccessible, and consequently it is not possible to give a reliable detailed account of the modes of occurrence of the veins worked. However, some sections have been exposed in the workings of the Matrix Reef syndicate from which the position of a rich vein in relation to the associated

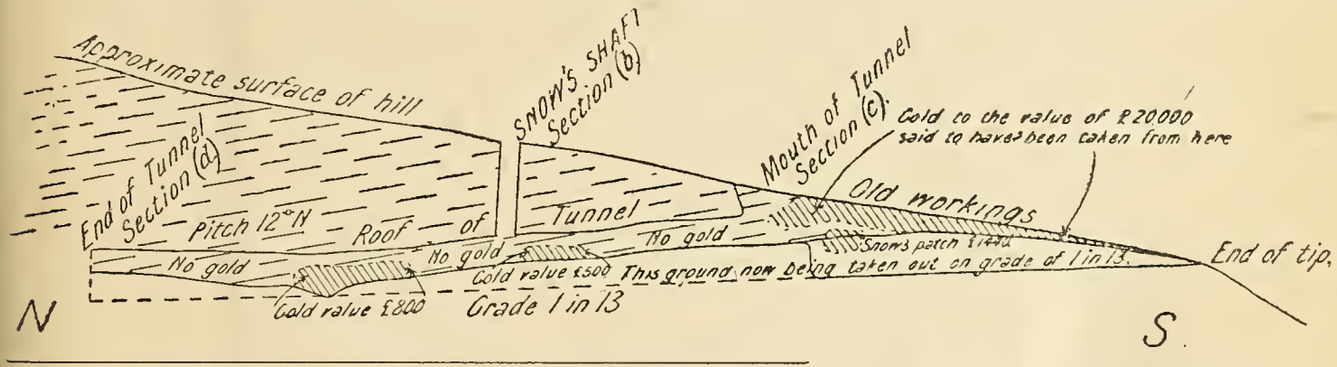



Fig. 13.—Section along Tunnel of Matrix Reef Syndicate. Scale, 80 feet to 1 inch.

rocks can be determined. It would appear from these that the greater portion of the work has been done on quartz veins occurring in and about a synclinal

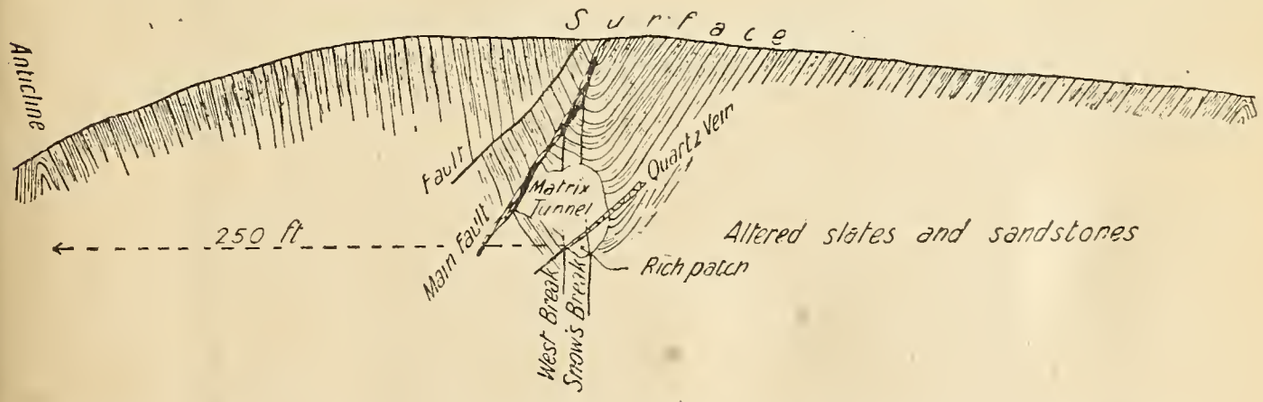
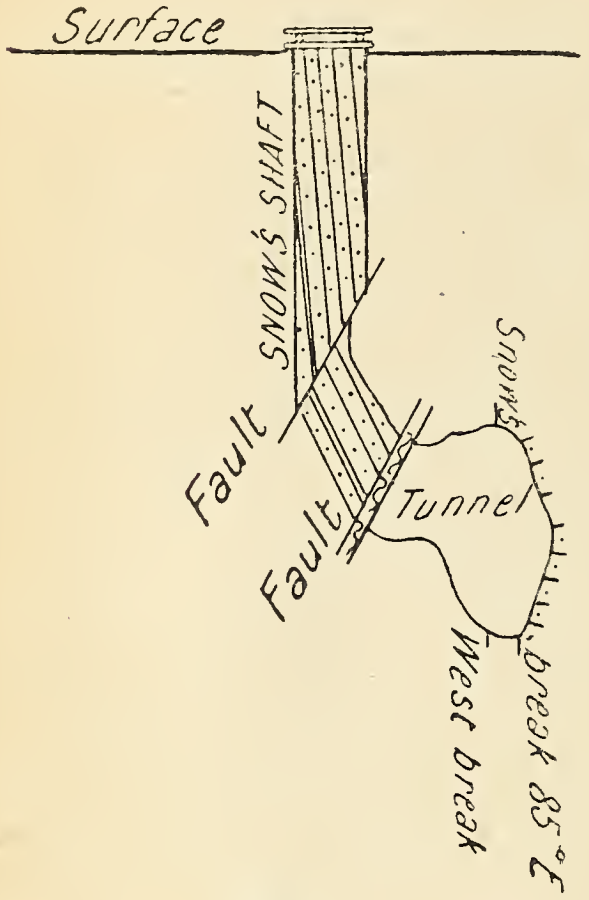



Fig. 14.—Ideal Section showing Position of Workings in relation to the Syncline. Not to Scale.

fold, the axis of which strikes N. 15° W. This fold has been fractured by faults, and judging from the position and description given me by the manager

(Mr. O'Brien) of the occurrence of the gold shoots in the quartz vein, it is safe to say that they occur only where the quartz intersects a lead-coloured clay slate in the immediate vicinity of these faults. Four faults are exposed in the Matrix tunnel. Three of them are clean cut—there is no dragging of the edges of the beds; the fourth carries between its walls 6 inches to 2 feet of fault rock, and displaces the strata considerably. It would seem that it is only to the eastward of—that is, under—this fault that payable gold has been found; the fault dips 48° to 60° W. Mr. O'Brien informs me that none of the workings on the western side discovered payable gold. Fig. 15 shows the positions of these faults; the main one is apparently younger than those



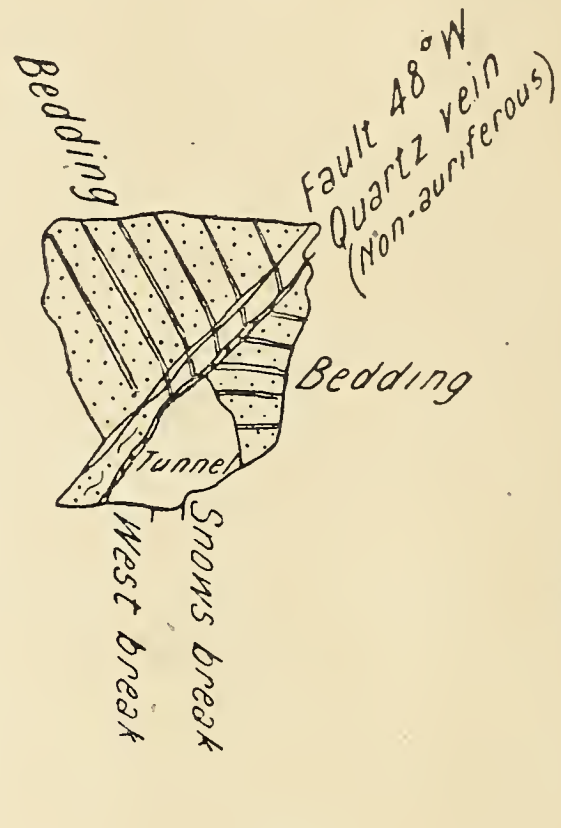



Fig. 15. Fig. 16. Fig. 17.

Figs. 15, 16, 17.—Transverse Sections showing Positions of Faults in the Matrix Tunnel. Scale, 20 feet to 1 inch.

marked Snow's break and West break, which traverse the strata generally in a vertical direction, and parallel in strike to the synclinal axis. The vein worked by the Matrix Reef syndicate varies in thickness from 2 inches to 12 inches. In places it throws down spurs, giving 2 feet to 3 feet of crushing material. It dips to the west at an angle of 40° to 50°, crossing the strata which in the tunnel dip east at 50° to 60°. Its line of intersection with the strata pitches 12° N., and is identical with the pitch of the syncline. The shoots of gold are small, irregular and discontinuous, but remarkably rich. The vein between the shoots is quite barren, or at any rate does not exhibit visible gold.

The work performed by the present claim-holders consists in extending an old tunnel 100 feet from Snow's shaft (see Fig. 13). About midway along this drive a rich patch of specimens was met with. The quartz containing the gold is highly ferruginous, and the gold is of very high quality. The specimens which were valued at £800 occurred between the West and Snow's breaks, and were confined between the floor of the tunnel and a line about 2 feet above it. As the longitudinal section (Fig. 13) shows, the tunnel (180 feet in length) up to the spot where the last shoot was found, followed the quartz vein down the angle of pitch of the country. Beyond this shoot the

floor of the tunnel was made to rise, and so has traversed country above the intersection of the vein and the favorable bed. The manager recognises this, and is now regrading the tunnel, and laying a tramway in it at an angle of 4½°. When the new floor has reached a point below the face of the present tunnel better conditions will exist for further prospecting. Should another shoot of gold be discovered, the management will doubtless consider the advisability of sinking a shaft north of the present workings.

[9.3.10.]

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## THE CLUNES GOLD-FIELD.

*By W. Baragwanath, Senior Field Geologist.*

The Clunes gold-field consists of a small area of Ordovician rocks exposed in the valley of Creswick Creek, and entirely surrounded by basaltic flows from points of eruption to the southward.

The field, although small, is of historic importance, inasmuch as gold was first discovered here in June, 1851, by Esmond. The Clunes field was also for many years the possessor of the largest battery and treatment works in the State. At the present time, however, it is in a most depressed condition, no work being carried on except the cyaniding of old tailings.

The geological features have been deduced from the limited rock exposures. A main anticlinal axis runs meridionally through the line of workings. The reefs worked appear to have been bedded lodes on each side of the anticline dipping east and west. On the eastern side of the anticline at a distance of about 400 feet a syncline occurs around which the bedded reefs continue. Sections of the old mine workings fully illustrate these features. From a point near the Port Phillip south shaft a change of pitch from northerly to southerly occurs. This dome exposing the favorable beds in which the reefs existed led to the discovery of the gold-field. The strata at the surface outcrop consist of light coloured white and yellow, with occasional pink, slates, and sandstones. From a depth, however, black slates have been obtained. Judging by the plans of the old workings the larger bodies of stone associated with the main anticline did not extend to the surface, but were met with on the axis of the main fold.

The mines being all closed, and filled with water to creek-level, details of underground workings are not available except from the old mine plans, which show a continuous line of reef workings extending from the south of the Lothair shaft to the north of the New North Clunes, a distance of 1½ miles. Throughout this length various reefs were worked through continuously, while others were exploited only in places. A record of these workings is given in Smyth's *Gold-fields and Mineral Districts of Victoria*, pp. 293 and 829. A plan showing the workings from surveys, &c., by Robert Allan, is published in the Reports of the Mining Registrars, 30th September, 1891.

The various shafts and their respective depths, so far as I can ascertain, are :—

| | Feet. |
|---|---|
| South Clunes No. 4 (Lothair) .. .. | 960 |
| ,, No. 3 .. .. .. | 850 |
| ,, No. 2 .. .. .. | 900 |
| ,, No. 1 .. .. .. | 440 |
| Central .. .. .. .. | 500 |
| Clunes United Company .. .. .. | 700 |
| Criterion .. .. .. .. | 700 |
| Port Phillip South Shaft .. .. .. | 890 |
| Port Phillip North Shaft .. .. .. | 1,745 |
| Yankee .. .. .. .. | 730 |
| Victoria .. .. .. .. | 1,000 |
| New North Clunes (winding) .. .. | 1,400 |
| New North Clunes (pumping) .. .. | 1,000 |

From the surface to a depth of about 600 feet appears to have been largely worked, but below that depth the workings are more or less irregular, and although the shafts reached greater depths prospecting was not by any means thorough. Future work on the field lies below 600 feet. The total value of gold won from the mines above mentioned amounts to nearly £5,000,000, while the extensions both north and south may prove important. From information gathered, the reefs at the northern end pitched 30° N., while at the southern end of the Lothair workings payable reefs were reported to have been worked right up to a crosscourse.

Consideration of the geological structure revealed by cross-cutting should have led to the discovery of the reefs on parallel folds, but little appears to have been done in that direction. Eastward of the main line through the workings a parallel anticline probably passes through the main portion of the town. On this line prospecting may reveal payable stone, since reefs have been unearthed in the gardens attached to private houses in the town. A line of reef worthy of trial exists on the east side of the main road to North Clunes; from this, according to local report, gold was obtained, although not in payable quantity. The character of this reef, unless it is a large spur, suggests that it is in folded strata.

Owing to the overlying basalt few exposures are available for a comparison of the structure of the adjoining strata with that proved favorable for gold deposition.

The alluvial workings from the main line of reef run under the basalt in a north-easterly direction, and proved remunerative in the upper portions.

At the south end of the area surveyed the Ballarat and Clunes and the Bute and Downs companies worked alluvial trending easterly. This was in the deeper ground, very wet and heavy. The gutter was narrow, but auriferous.

The causes of the stoppage of the Clunes mines may be ascribed to financial difficulty in some mines, which, not being able to take their share in pumping, flooded the mines on payable stone, as the latter were not in a position to erect larger pumps. An amalgamation scheme was proposed, but, negotiations falling through, the companies were wound up, notwithstanding the recorded fact that large bodies of stone were opened up from which payable crushings had been obtained.

To reopen the old workings would require a considerable initial outlay, while continuous pumping would be subsequently required. The surface frames of most of the shafts have collapsed, but the repair of these is only a small matter.

SECTION A – B

*South Boundary of P.R*

# THE CLUNES GOLD FIELD

Showing Topographical and Geological Features

Contours 10 Feet Intervals

SCALE OF CHAINS

0 5 10 15 20

*Surveyed by W. Baragwanath, Senior Field Geologist, 1912.*

REFERENCE

- Alluvial.
- Volcanic.
- Ordovician.

BRITISH MUSEUM
NATURAL HISTORY

On the plan the sites of the main shafts are shown as near as was possible to locate them. The surface features and contour are also indicated, and the course of the deep leads at their inlet is given. It will be noticed that these lie considerably above the level of the present creek. A small patch of alluvial was recently worked in the Creswick Creek west of the Port Phillip. It is said that the northward extension of this was left unworked on account of heavy water.

[29.3.12.]

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## FORRESTER'S MINE, SMEATON.

*By W. Baragwanath, Senior Field Geologist.*

Forrester's mine is located in the southern portion of the Smeaton Hill P.R., parish of Smeaton, about 2 miles southerly from Mount Kooroocheang. In the vicinity of the mine a small area of Ordovician bedrock occurs, entirely surrounded by basaltic and newer deposits, beneath which deep leads of payable character have been worked. This refers more particularly to the north and east of the present shaft.

Forrester and party, supported by a local syndicate, have been at work for the past twelve months in the neighbourhood. From a shaft some distance west of the present one auriferous quartz was obtained, but not in sufficient quantity to pay expenses. Some months ago work at the present site, which is about 150 feet north of the old Kooroocheang company's shaft, was begun. The shaft is sunk 65 feet, and at that depth cross-cuts east 97 feet and west 70 feet were driven. The strata passed through, where visible, consist of slightly altered slates. At 25 feet east of the shaft a spur on a fault dipping about 45° west was driven on north 50 feet and south 25 feet. At 15 feet north of the cross-cut a rise above the fault exposes two parallel vertical makes of stone 3 feet apart, each averaging about 6 inches in width; this rise is up 19 feet. From the drive north of this rise a trial crushing of 8 tons of stone treated at Creswick yielded 8½ dwt. of gold per ton. From the cross-cut at the intersection of a spur a winze has been sunk to 17 feet. Two well-defined vertical formations show throughout the depth of the winze, the western averaging 12 inches and the eastern 6 inches, with cross-spurs and strata between. At 3 feet below the main level a cross-spur connects the two formations. This spur has given highly payable dish prospects. The verticals in the bottom of the winze yielded a payable prospect when sampled during this visit.

As to the future working, the double handling of stone from the winze will prove costly. It is therefore advisable to sink the shaft to a depth of, say, 90 or 100 feet, and open out a cross-cut east at that depth, where driving on the lode or verticals will prove the value away from the influence of the slide or fault which has disturbed the lode at the 65 feet level.

While this work is in progress, a trial crushing might be stoped underfoot in the north drive from the winze already sunk. This should yield a margin of profit after paying all expenses.

At 45 feet from the surface a small cut has been put in west, and a drive opened on a spur which is of low value.

The locality possesses more than ordinary interest from the fact that rich alluvial has been traced to the surface in the vicinity, and also that fossils

similar to those obtained from the gold-fields of Bendigo, Castlemaine, and Daylesford, in the vicinity of the richest mines, are met with within 200 yards of the present workings.

[22.11.12.]

Certain works recommended in my report of 22nd November, 1912, have since been undertaken, but the results have not come up to anticipations. The shaft at the date of my previous visit was 65 feet deep, with a cross-cut east 25 feet to two vertical makes of quartz on which a winze was being sunk. Since then the shaft has been deepened, and a cross-cut east opened at 93 feet. At 25 feet from the shaft a fault dipping west was met with, and the vertical makes of quartz showed only as a wedge in the back. On rising on this stone a connexion was made with the winze from the level above, but, not meeting with the stone below the slide, some of the party have formed the idea that the stone is of limited extent. From the features exposed there is nothing to warrant this idea, as the fault makes a clean break in the stone, which will be found again below the level. Two methods of locating the stone below the slide are suggested, viz., to drive northerly under the slide which pitches south, or to sink the shaft, say, 20 feet and cross-cut. From indications, I would anticipate a displacement of under 20 feet by the slide; this would place the reef nearer the shaft below the present cross-cut, and on the east side. From the fact that the stone above the slide is auriferous, and a trial crushing of 10 tons from the winze gave 5 oz. 10 dwt. of gold, the testing of the formation below the slide appears justifiable. At present some 25 feet of backs above the lower level and beneath the top slide are available, and these, if supplemented by an additional quantity below the lower slide, should induce the prospecting party to develop further what appears to be a promising locality.

The lower level being below water-level, a quantity of water—2,000 gallons per diem—has to be baled, but it is not anticipated that any material increase in quantity would be met with in, say, 25 feet of further sinking.

By driving south at a lower level the quartz above the slide may be tested, but I would prefer to see the shaft deepened and the formation tested at a depth.

[29.3.13.]

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## DEAN'S MARSH COAL MINE.

*By Stanley Hunter, Engineer for Boring.*

The Dean's Marsh Coal mine is situated about 7 or 8 miles from Dean's Marsh, on the road to Lorne. The coal seam is in a Tertiary deposit of sand, clay, &c., resting on Jurassic sandstone. The area of the Tertiary deposit is probably not more than 100 acres, while the area of the coal seam will certainly be much less, and may occupy not more than 15 or 20 acres. The seam varies from 5 to 6 feet in thickness, with a general dip to the north-west.

The method adopted to develop the seam was by dip-tunnels. A pair of shafts at the dip end of the seam would have been the proper method.

These dip-tunnels were put in close to the creek and on the outcrop of the coal. The first flood filled the workings. A tail race was then constructed, but the creek water still gave trouble, and as no pumping machinery had been considered necessary the mine had to be abandoned. A railway line was brought in from Dean's Marsh at considerable cost, and a very poor system of rope haulage from the tunnel to the top of the ridge, along which

the railway ran, was installed. Some thousands of tons of coal were taken out and retailed in Geelong at £1 per ton. It is very fair household coal, but too light for locomotive or forced draught work. Had a proper boring scheme been carried out at only a very moderate cost (say, £250), the exact position of the seam would have been located, and possibly a better method of mining adopted.

It would certainly not pay any company now to attempt to reopen the mine, owing to the ramification of old drives through the thickest portion of the coal and to the limited quantity of coal available.

[20.11.12.]

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## THE LORD TENNYSON REEF, WELSHMAN'S GULLY, EGANSTOWN, NEAR DAYLESFORD.

*By A. M. Howitt, Field Geologist.*

The beds adjacent to the Lord Tennyson reef are Ordovician slates and sandstones, which strike N. 20° W., and dip both east and west at angles varying from 60° to 70°.

The reef is a lenticular laminated quartz block, with an average width of 1 foot, bulging to 2 feet in width near the middle, and in strike it cuts the beds at a big angle.

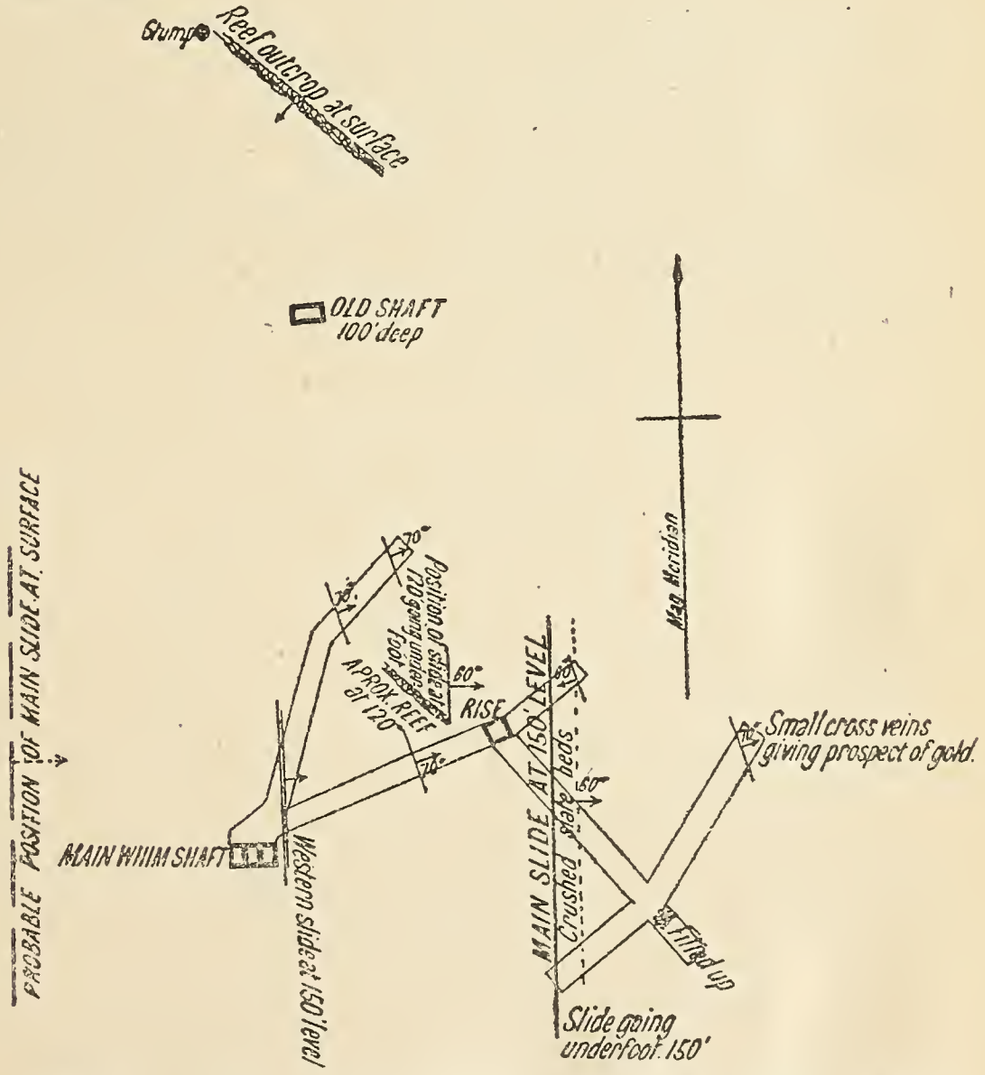


Fig. 18.—Plan. (Compass Survey). Scale, 40 feet to 1 inch.

Originally this reef was worked by a party holding the ground under lease, but the present holders are working under miner's rights.

From the surface to 95 feet deep the reef was payable and up to 30 feet in length, but water trouble caused the mine to close down.

Six months ago Osborne and party took up the ground, and decided to sink a new whim shaft 70 feet to the south of the old windlass shaft. This shaft they sank 150 feet, timbered it closely in three partitions, and erected a whim, intending to cut the reef on its south pitch, and stope up to the old workings.

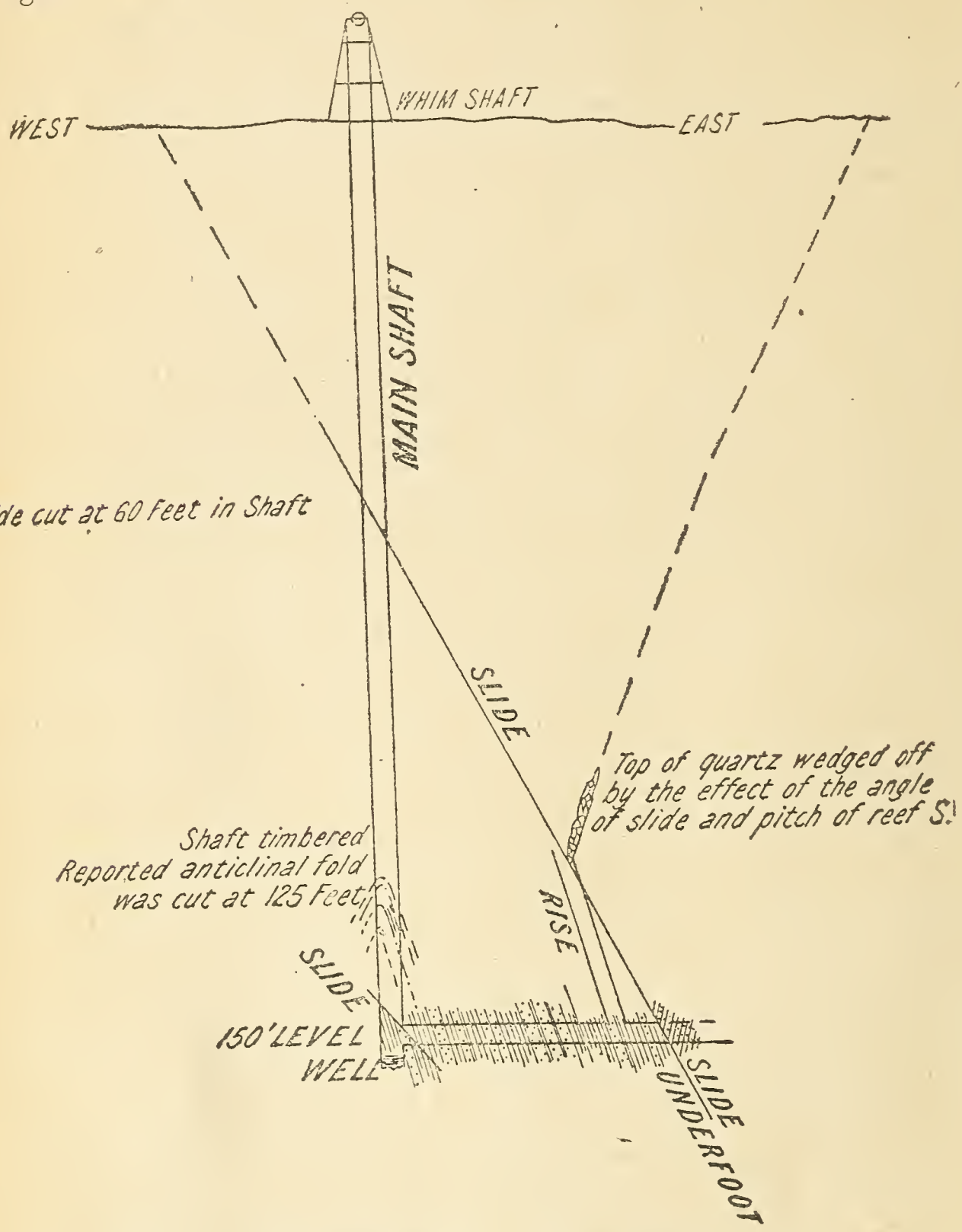


Fig. 19.—Transverse Section. Scale, 40 feet to 1 inch.

Their cross-cut at the 150-ft. level failed to cut the reef, and continuing on they passed through a slide to the east of where the reef should have been, so a rise was put up at 40 feet to the north-east of the shaft, and the reef found on the slide at a point about 30 feet above the 150-ft. level, thus allowing them very little of the reef to stope out.

The reef strikes W. 40° N., underlies 70° to the west, and pitches to the south-east at an angle of 60°. The slide strikes N. 1° W., and dips 60° to the east, so the intersecting angle of the reef and slide is about 30°, causing the appearance of a wedge, where the reef cuts off to the south-east on the slide.

The beds which can be examined above the slide appear to dip 70° to the west in the north-east cross-cut 15 feet from the rise, but where I could note them elsewhere they had a dip of 60° to 70° to the east.

Mr. Osborne informed me that in sinking the main shaft an anticlinal fold was cut at 120 feet deep, but the close timbering now obscures this from view, although an anticline should occur near the shaft, as there are western beds in the gully to the west of the shaft.

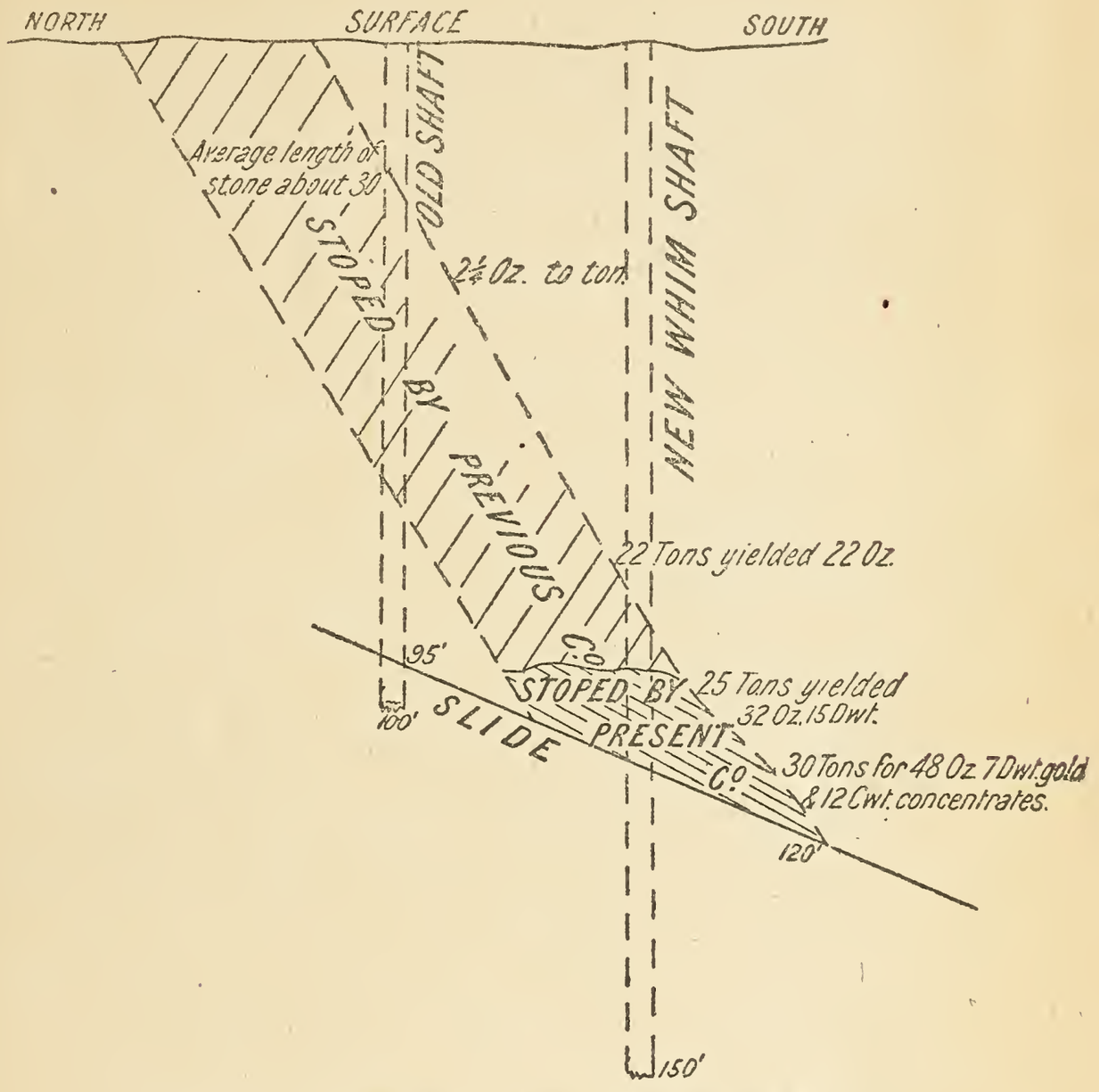


Fig. 20.—Longitudinal Section. Scale, 40 feet to 1 inch.

The slide is strong, having black pug along it and crushed beds above. The direction of the movement cannot be definitely stated, but it is probably to the east, as a little quartz has been seen near the slide that way.

To the west of where the reef was lost the country has been already tested to some extent by a cross-cut, and the main shaft showed nothing below where the slide cut through it at 60 feet; but there is still a portion of the country to the west of the shaft of which nothing is known.

If, as seems probable, the lower portion of the reef lies to the east, then it will have to be looked for to the east of where the slide goes underfoot in the 150-ft. level, and this would necessitate further sinking of the main shaft, and cross-cutting towards the slide again. This would be purely prospecting work, as no estimate can be formed of the amount of movement.

Whatever future work the party decide to carry out in trying to locate the reef, they must take carefully into consideration the westward dip of the reef, and particularly its pitch to the south. On account of its shortness this reef will be much harder to locate than if it had been in a better-defined channel extending for some distance.

Yields up to 2¼ oz. to the ton have been obtained, and the two last crushings gave—

25 tons for 32 oz. 15 dwt.
30 tons for 48 oz. 7 dwt.

The present party have earned only about £11 per man for their six months' work, for after paying heavy expenses in putting up the whim and sinking a main regulation shaft there was little profit left from the crushings. At present the water can be kept down by a few hours' baling with the tanks each day.

[20.8.08.]

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## UNEXPLAINED NOISES IN THE DAYLESFORD DISTRICT.

*By W. H. Ferguson, Assistant Field Geologist.*

In the Daylesford district sounds resembling explosions, which could not be traced to any mining or quarrying operation, are said to be heard at intervals. When at Shepherd's Flat, Yandoit, and the Pickpocket Diggings, between Clydesdale and Newstead, I made inquiries as to whether the sounds were heard at these places, and, being assured that they were, several people were asked to point out the direction from which the sounds appeared to come. Compass bearings were then taken to the points indicated. One bearing was taken at Shepherd's Flat, one at the village of Yandoit, 5 miles to the north, and one at the Pickpocket Diggings, about 3 miles further north. The bearings intersect within a circle of 50 chains in diameter in the eastern portion of the parish of Campbelltown.

The sounds are described as resembling thunder or the explosions made in blasting rocks; they may occur singly, or two may be heard in rapid succession, and more frequently in wet than in fine weather. They have been heard at intervals for a number of years, and a resident of Yandoit informed me that the noises are there known as "Pat Hanley's guns," as a land-owner of that name at one time lived near where the sounds are supposed to originate.

The noises are said to come from a portion of the Yandoit hills known as the Stony Rises, near a branch of the Green Gully Creek. The residents are of the opinion that the sounds are caused by explosions of gas, and state that birds and rabbits which were supposed to have been suffocated by gas have been found dead in hollows of the ground.

This portion of the parish of Campbelltown was not visited, but an inspection of the geological map of the parish shows that basalt has flowed down a branch of the Green Gully Creek, and remnants of the flow exist as a series of low hills. These trend down the creek, which may have been eroded along the strike of the Ordovician rocks, or possibly along a fissure. Noises like those described by the residents of the district have been heard in many places in other countries, and are now generally known as brontidi (like thunder); in India they are known as barisal (guns), in Mexico as bramidos (bellowings), in Italy as marina (sea shore). In some instances they precede earthquake shocks or volcanic eruptions; in others they increase in frequency and then gradually die out without any earthquake or volcanic disturbance. It is not certain that these Yandoit noises are really brontidi, but it is not at all improbable that they are. The bearings taken indicate that the noises proceed from a part of the parish

through which there apparently passes a line of weakness, the surface indications of which are a line of mineral springs (one occurring on Joyce's Creek, on the Maryborough-Newstead road, the other on Deep Creek, on allotment No. 54[A], parish of Campbelltown), and on the southern extension of this line is a line of fissure eruption in allotments Nos. 91 and 93, parish of Bullarook. It is possible that the noises originate along a fault line, and that movements are yet taking place, and these cause the sounds that are heard.

There is another possible explanation, for the locality where the sounds are heard is volcanic, and the part indicated by the bearings is within 5 miles of Smeaton Hill or Mount Kooroocheang, an extinct volcano where faults are known. About 10 miles south of the locality where the supposed brontidi emanate three extinct volcanoes, Eastern Hill, Mount Prospect, and Langdon's Hill, indicate a line of fracture of the earth's crust. If this line be produced northwards it would pass close to where the sounds are supposed to originate.

[30.3.11.]

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## THE GOLDEN HOPE MINE, NEAR BLAKEVILLE.

*By W. H. Ferguson, Assistant Field Geologist.*

The Golden Hope mine, formerly known as the Ragged Thirteen mine, is situated on the ranges about 1 mile north-easterly from Blakeville, about 8 miles north of Ballan; and about 7 miles south of Bullarto railway station. I went to the mine from Bullarto, but the best way is from Ballan, as there is said to be a good road to within 1 mile of the mine. The road from Bullarto is only a rough bush track, so cut up by timber jinkers, that it is impassable to light wheel traffic. From old Bullarto, which is 1 mile south of the Bullarto railway station, a ridge runs south to Blakeville, and reaches an elevation of upwards of 3,000 feet above sea-level. Near Bullarto a considerable amount of slate outcrops, and the soil is of medium quality and red in colour; about 2 miles south there is a change, and more sandstones and grits come in; the soil is then poor and sandy in quality and white in colour, and the timber is stunted.

A reef runs with the strike of the country rocks, nearly north and south, but the main feature of the mine is a gold occurrence in a dyke. The dyke varies somewhat in different parts of the mine; it passes from a felsite to a felspar-porphyry and to a quartz-felspar-porphyry of fine grain. Near the surface the rock contains hollow spaces from which cubes of iron pyrites have been leached out, and at a depth it contains small cubic crystals of iron pyrites scattered throughout the rock. The dyke appears to strike north and south with the country rocks as well as could be judged in the mine workings, and it is 100 feet wide, measured from the west, where it is bounded by slate to the drive on the east, which has not reached the eastern wall as it was discontinued in kaolin. In one or two places the dyke encloses a narrow band of slate, and on the western wall there is 1 foot of crushed fault-rock, mostly slate, indicating a movement plane. The intrusion of the dyke appears to have effected little or no alteration in the adjacent slates. At the western end of the 70-ft. level the western wall of the dyke dips east at 65° agreeing with the dip and apparently with the strike of the country rock; as there are several inclusions of slate in the dyke this may not be the true foot-wall, and there is a possibility of it being further west.

The gold does not occur evenly distributed throughout the dyke-stone, but appears to be confined to quartz leaders and threads. The principal veins

in the mine are two "floors"; these are movement plains carrying quartz veins, which extend across the dyke from east and west, and pitch N. 10° W. at about 20°. In one of them there is an inch or two of pug or kaolin. The quartz ranges up to 1 foot in thickness, and above and below the floors small quartz leaders irregularly intersect the dyke-stone and form a stockwork. It appears as though solutions have deposited auriferous quartz in and close to the fissures, and also to a less extent throughout the dyke-stone. The main floor reaches the surface a few feet south of the south shaft, and it has been proved to a depth of 70 feet at the bottom of the 70-ft. shaft, a distance along the pitch of 115 feet. From an inclined drive crushings have been taken out along this floor, and also easterly and westerly along the 70-ft. level. It is stated that the ore was taken out for a thickness of 5 feet in places.

Several crushings yielding 15 dwt., 1 oz., and 2½ oz. to the ton have been obtained. A small crushing from above the roof of the upper floor yielded 17 dwt. to the ton, and 200 tons have been crushed for an average of 1 oz. 15 dwt. of gold to the ton; one small very rich crushing was obtained. The north and south reef gave up to 7½ oz. of gold to the ton. As the manager was not at the mine, complete details of crushings were not obtained. It is considered from the results of the various prospecting operations that there is a portion of the dyke upwards of 50 feet thick, pitching north and intersected by quartz floors, veins, and leaders carrying gold, which, with proper machinery, would pay to work. On the dump there was nice gold in quartz leaders in the dyke stone as well as in the quartz in the roof at the 70-ft. level.

The north and south reef is about 2 chains west of the shaft on the dyke. It is not opened up much, but a vertical shaft has just been started on it. At the surface south of the shaft it carries about 1 foot of quartz, and in the shaft it appears to be dipping with the country rock to the east. There is no machinery on the mine, and the shaft is being worked with a windlass.

The dyke has been proved auriferous to a vertical depth of 70 feet, and the payable floor extends across the dyke upwards of 100 feet.

There is both low-grade and rich ore in the mine. It would not be wise merely to follow the latter, but the property should be thoroughly proved, and then suitably equipped to deal with all the payable auriferous ore. Timber is abundant, and Potter's Creek flows just below the mine.

The dyke is said to have been traced for many miles north and south of the mine, Abel's mine, 2 miles to the north, being mentioned as one of the places where it has been located. On searching the spot mentioned grit bands were found, but no dyke. Similar rock is well developed at Blackwood and Blakeville, and has been noted at Rocky Lead, Steiglitz, and other places. It has been formed from the breaking down of granite, and is composed of grains of quartz and felspar up to ⅓ of an inch in diameter. This rock has frequently been confused with a quartz-porphyry dyke-stone, but the grit bands contain more quartz grains than the dyke-stone and have less base; they also contain grains of black quartz and an occasional fragment of slate. If the decomposed grit be rubbed between the hands and panned off, the residue will consist of coarse sand and larger well water-worn quartz grains.

The dyke should be traced as far as possible north and south, and it is very probable that other quartz-porphyry dykes may be found in this country, for at Rocky Lead, about 8 miles north-west of Blakeville, there is one of the same series of dykes from which a little gold has been obtained.

The workings at the Golden Hope mine illustrate how important it is that prospectors should thoroughly loam and otherwise prospect any dyke met with, for, throughout the State, many of our gold occurrences are associated with dykes of one sort or another. The Victory dyke at Foster, from which

much gold has been obtained, appears to be almost identical in composition and structure with the Golden Hope dyke. Some of the same series of quartz-porphyry dykes occur on the Werribee between Bacchus Marsh and Ingliston.

The Golden Hope dyke and reef occur in the slate and sandstone series of the Lower Ordovician rocks, and the beds may be found to belong to the Bendigo series, for at Abel's Reef, about 2 miles north, a small collection of graptolites was made, which are probably Bendigonian. The rocks are not like those of Bendigo, being more sandy and gritty, but this may possibly be due to their having been formed nearer to where granite rocks were being disintegrated. These beds southwards may pass near Ballan, and northwards may perhaps trend a couple of miles west of Castlemaine.

An unidentified green mineral, which is soft and crystallizes in cubes or in clusters of radiate acicular crystals, occurs in the quartz veins in the dykes, and coats the small quartz crystals.

[2.10.11.]

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## FREESTONE QUARRIES AT GREENDALE, NEAR BALLAN.

*By W. Baragwanath, Senior Field Geologist.*

The freestone quarry, situated 30 chains north-west of the Medway Hotel, Greendale, in allotments 8 and 9 of section V., village of Greendale, and on the western bank of a small stream, was first opened over forty years ago. A fair quantity of stone has been obtained, and the most remarkable feature is the absence of any spoil bank, the entire amount taken out having been utilized. A face of over 20 feet in height shows even-grained white to light buff sandstone resting on a thick bed of pebbly mudstone. The largest of the sandstone beds is over 8 feet in thickness, and even in grain and colour throughout; then there are a few thin shaly layers followed by other beds of even-grained sand-stones. Southward and higher up the hillside large beds are exposed; these would come into the face of the present quarry as work proceeds into the hill.

Another quarry lies ½ mile east of the Medway Hotel on the eastern slope of a steep hill, about 200 feet in altitude. A bed of sandstone, 10 feet in thickness, of fine even grain, and of a faint pink colour ranging to light yellow, is exposed, resting, as in the other quarry, on a bed of pebbly mudstone. About 80 feet higher up the hill a still thicker bed of somewhat coarser grain was noticed, but apart from proving its thickness nothing has been done.

The existence of a great quantity of suitable material is assured. From the two exposures, stone of different colours, free from any objectionable features, and in any sizes consistent with the requirements of transport can be obtained. The stone in the quarry east of the hotel has a colour and grain which should cause it to be much sought after.

The durability may be judged from stone quarried forty years ago. Two culverts on the Ballan-road built of rough hewn blocks are still as good as when first erected. The pick marks are not even obliterated, although the conditions to which the stone is subjected are severe.

In Greendale township a bridge built of bluestone is faced with freestone. Here no sign of fretting or weathering is evident, even on the sharpest corners.

There is a small church in Greendale township built of this stone. It is apparent that economic considerations or lack of knowledge led to the utilization of stone which should never have left the quarry, but the durable

nature and pleasing colour of the stone obtainable is strikingly apparent. With the exception of a few odd pieces of shale of high colour, which should never have been used, the building after forty years is as fresh in appearance as if just built. Good examples of the suitability of the stone for dressed surfaces are to be seen in the window openings, &c. The foundations below ground consist of freestone, and their contact with the surface soil shows no deterioration.

From a geological stand-point the formations belong to the Bacchus Marsh series (Permo-Carboniferous) and show striking evidence of deposit under glacial conditions, the pebbly mudstones being visible in both quarries. Jointing of the sandstones is markedly absent in both localities, which forms a striking contrast to the beds in the same series further south. The ease with which the stone can be cut while in the quarry, followed by a hardening on exposure, is a good feature. The dip of the beds in the quarry north-west of the hotel is to the north-west, while in the eastern quarry, the dip is south-west at about 10°. In both cases the beds dip under the hill. While both faces exposed show extensive deposits, further prospecting on careful lines would probably prove more economic places for the openings. In this direction opening the bed in the western quarry to the north is suggested, so that the face could advance up the incline of the dip of the beds. In the eastern quarry the bed could be traced southwards, and a face opened that would similarly work in an uphill direction. These and the best means of extracting the stone are mere matters of detail.

To summarize, large beds of easily obtained freestone of pleasing colour, with undoubted resistance to weathering and free from jointing, staining, or objectionable features, are exposed. The distance to the railway is about 6 miles, with a good road throughout. Having such favorable deposits within easy access of the metropolis should cause attention to be directed to them, as no doubt large quantities could be used in building.

[6.3.11.]

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## SIMS' QUARRY, MOORABOOL RIVER, BALLAN.

*By W. Baragwanath, Senior Field Geologist.*

Several quarries are situated on the banks of the Moorabool River, on the northern side of the Ballan to Egerton road.

The first is about a quarter of a mile above the bridge on the Ballan-Egerton road, while the second is about a quarter of a mile further up stream, both being in the north-eastern corner of the parish of Bungal. The formation exposed in both quarries belongs to the Bacchus Marsh glacial series, which is exposed on the southern bank of the Moorabool to the north of Hunterston pre-emptive right. The work done in the up-stream quarry is small, and, in the lower quarry, the stone is soft and friable, and full of joints. About 30 feet above the latter quarry, however, the remains of an old cut can be seen. This, it is stated, is the site from which came the freestone of which Hunterston homestead was built 60 years ago. The good state of preservation of this building is evidence of the suitability of the stone for building purposes. In this upper cut is exposed a bed of freestone 12 feet or more in thickness, white and fine grained, capable of retaining sharp corners, and apparently free from joints. The weathered portions of this old cut show the stone to be one of superior quality. A face should be cut in this formation to prove its extent. In the most northerly quarry, which is also on the bank of the

Moorabool, a fine face of white freestone with an underlying 2-ft. bed of pebbly mudstone is exposed. No attempt to open up the formation systematically has been made here, but a kind of trench or open cut from the top of the hill to near water-level has been shot out, filling the lower portion with the excavated material as broken. Although thus roughly treated, some fair blocks of stone of good quality can be seen in the mullock.

The extent of the formation was not determined, but a length of over 30 chains is exposed in the Moorabool River. Overlying the area Tertiary deposits occur in places. To test properly what appears to be a good deposit, a face might be made on the top seam a quarter of a mile from the bridge, and a good cut put in at the upper quarry.

The quarry is 2 miles south of Bradshaw's Creek railway station, to which a tramway along the Moorabool River, to connect with the Ballarat-Melbourne line, could be easily constructed if the works suggested above were successful.

[17.11.11.]

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## ALLEGED OCCURRENCE OF MINERAL OIL AT ANGLESEA.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

From Geelong, *via* Torquay, Anglesea is 27 miles distant, and is situated on the coast at the mouth of the Anglesea River. Between Torquay and Anglesea is a Tertiary plateau about 400 feet above sea-level, with a steep descent to Anglesea. On both sides of the river limonite in moderate quantities is exposed on the Tertiary hills, generally much intermingled with quartz sand or pebbles. On the beach this ferruginous conglomerate stands out conspicuously on the west side of the mouth of the Anglesea River, and about half a mile still further west.

The coastline is marked by Tertiary cliffs from a few feet to 200 feet in height, and the sea is continually encroaching on these. In the cliffs the beds are well exposed. An anticline runs in a northerly direction about 20 chains to the west of the mouth of the Anglesea River ; the arch starts near the river, and dips under sea-level about three-quarters of a mile to the west. Black carbonaceous mudstone occurs at sea-level and rises for about 30 feet above sea-level at the anticline half a mile west of the river, and above this are beds of yellowish-grey and grey silts, with some thin bands of carbonaceous mudstone. Beds of what appears to be volcanic ash about 4 feet thick occur above these beds, and on top of this again are red and grey mottled beds, apparently Newer Pliocene in age.

Half a mile west of the Anglesea River the cliff section exposed to sea-level is :—

| | feet. |
|---|---|
| Surface soil .. .. .. .. | 2 |
| Grey and drab beds .. .. .. | 120 |
| Black carbonaceous mudstone .. .. | 40 |

Close by two bores were put down on the beach to a depth of 90 feet, all in black mudstone. From one of these holes it is stated an escape of gas took place, and that black mud was ejected from the bore-hole. The Anglesea River appears to run in a syncline, and a few chains to the east on the coast the black carbonaceous beds rise above sea-level. The beds appear to have not only been bent over in a wide fold, but also to have been faulted. Some boring to about 70 feet in depth was done on the east side of the river.

The grey beds along the cliffs have an appearance and colour that would suggest that they were calcareous, but there is a total absence of lime in them. Yellowish-grey concretions are common in these beds, and some of this material

fills joints and cracks in the black carbonaceous beds. The concretions consist of 28·2 per cent. of hydrated oxide of iron (principally ferric iron), alumina and a large proportion of fine silica. As a pigment this material, when burnt, possesses some good qualities. The grey beds in which the concretions occur consist of fine soft sandstone with a little ferruginous matter.

The black carbonaceous beds are the most interesting. An analysis of an average sample from the cliff on the east side of the river was made in the Geological Survey Laboratory and gave the following results :—

| | per cent. |
|---|---|
| Moisture .. .. .. .. | 17·34 |
| Carbonaceous matter .. .. .. | 9·28 |
| Ash .. .. .. .. .. | 73·38 |
| | 100·00 |

The ash, on partial analysis, gave :—

| | per cent. |
|---|---|
| Silica .. .. .. .. .. | 81·8 |
| Alumina .. .. .. .. | 8·9 |
| Iron .. .. .. .. .. | 4·6 |
| Calcium .. .. .. .. | Nil |
| Magnesia .. .. .. .. | 1·5 |
| | 96·8 |

In the bed of volcanic ash iron pyrites is plentifully present. The fine siliceous sand on the beach appears to be directly derived from the wearing down of the cliffs.

Mr. Deans, of Geelong, has persistently bored in this neighbourhood for mineral oil, but hitherto with no success. At the surface there is no evidence that it exists, but great stress is laid on the fact that gas at two of the bores ejected black mud churned up in boring. This in itself is no evidence that such oil exists. What may exist at a greater depth it is impossible to say.

[23.8.11.]

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## MAGNESITE AND CLAY AT SPRING CREEK, ROWSLEY, NEAR BACCHUS MARSH.

*By D. J. Mahony, M.Sc., F.G.S., Petrologist.*

The magnesite deposit in this locality is situated in the valley of Spring Creek, on Mr. D. O'Keefe's farm, section 5G, parish of Bungeeltap, about 6 miles west of Rowsley railway station, and 12 miles from Bacchus Marsh. The valley is steep sided, about 200 feet deep, and the rocks exposed are basalt, about 60 to 80 feet thick, resting on a series of Tertiary clays. The magnesite is found near the creek-level where it occurs in nodules ranging up to 30 or 40 lb. in weight and irregular in shape. It is also found in a shot-like form, and has a fairly soft clay-like material; the last is exceedingly difficult to distinguish from the white clays which are abundant in the vicinity. The magnesite nodules are fairly abundant in the creek bed, and one small hole that has been sunk exposes hard nodules embedded in the softer form of the same material, but until some more work is done it is impossible to judge the extent of the deposit. It might be tested by sinking holes wherever there are

favorable signs. Owing to the soft nature of the clay and the land-slips on the sides of the valley, there would be considerable difficulties in the way of mining operations.

It appears that this magnesite is in its natural position, and has not been carried down from a higher level by a landslip. One nodule resembling magnesite was found just below the level of the basalt, but this proved to be too rich in lime to be of commercial value (No. 3 below).

Analyses were made in the Geological Survey Laboratory.

| | No. 1. per cent. | No. 2. per cent. | No. 3. per cent. | No. 4. per cent. |
|---|---|---|---|---|
| Carbonate of magnesia | 96·44 | 95·45 | 67·21 | 80·59 |
| Carbonate of lime | 1·65 | 3·10 | 29·93 | 5·67 |
| Alumina and iron | 0·06 | 0·05 | 0·09 | 0·23 |
| Silica | 0·09 | 0·15 | 0·83 | 11·27 |
| Water above 110° C. | 0·62 | 0·65 | 1·92 | 2·24 |
| Water below 110° C. | 0·98 | 0·20 | | |

No 1. Hard nodule of white magnesite from the creek bed.

No. 2. Soft, clay-like magnesite enclosing harder nodules; hole sunk near creek level.

No. 3. Nodule from about 80 feet above the level of the creek and near the base of the basalt.

No. 4. Nodule from the creek level; it has a rough surface unlike the usual type found in this locality.

In the following table[1] the composition of magnesite from some of the best known foreign localities is shown for the purpose of comparison :—

| | No. 5. per cent. | No. 6. per cent. | No. 7. per cent. |
|---|---|---|---|
| Carbonate of magnesia | 92 to 94 | 93·0 | 85·5 |
| Carbonate of lime | 1·10 to 3·20 | 0·12 | 1·20 |
| Alumina and iron | 1·75 to 3·20 | 0·85 | 3·50 |
| Silica | 1·0 to 2·0 | 5·6 | 0·75 |

No. 5. Magnesite, Greece; 56,797 metric tons raised in 1909.

No. 6. Magnesite, Silesia
No. 7. Magnesite, Hungary } 125,666 metric tons raised in 1909.

It is evident that the best Spring Creek samples compare very favorably with the foreign examples, especially No. 1, which represents the type usually found as hard nodules in the creek bed. For industrial purposes the percentage of magnesium carbonate ($MgCO_3$) should be high and the calcium carbonate ($CaCO_3$) low.

In 1910 the total consumption of magnesite in the United States was 178,327 metric tons, valued at 1,602,580 dollars, giving an average value of £2 per ton in British units.

Up to the present time Heathcote is the only place where magnesite has been mined in Victoria, but it has been reported to occur at Hard Hills, near the junction of Jim Crow Creek and the Loddon River, and at Bulla in the kaolin beds.

## Clay.

Overlying the magnesite deposit there is a considerable thickness of white clay. Half-a-dozen samples were taken and submitted to the usual briquetting test, which consists of making them up into tiles which are first air-dried and then burnt at various known temperatures. They produced excellent light-coloured tiles at moderate temperatures, but are not suitable for fire clays. They should be suitable for the manufacture of vitrified ware. Some of these clays contain fluxes, and are inclined to fuse, but this effect could be counteracted if the materials proved otherwise suitable.

[1] Mineral Industry, 1910.

General Notes on the Geology of the District.

The clay and magnesite form part of the extensive lacustrine deposits of the Bacchus Marsh district. From the enclosed fossil vegetable remains, which occur plentifully in certain places, these beds are usually considered to be of older Tertiary age. In the vicinity of Rowsley the whole deposit has been covered by a sheet of basalt, but since this rock was poured out by the volcanic agencies many deep valleys have been cut out by the Parwan and its tributaries. Close to Mr. O'Keefe's farm the Brisbane Ranges, which are formed of Ordovician slates and sandstones, begin and extend in a south-westerly direction. It is extremely probable that the south-eastern face of these hills marks a fault line, which is continued both northerly and southerly as a basalt escarpment separating basalt plains which occur at different levels. The top of the basalt plateau at Mr. O'Keefe's house is about 1,030 feet above sea level.

In regard to the origin of the magnesite it is very probably formed by the percolation of water containing carbonic acid through the clay. Such water would attack decomposing magnesian silicates and convert the magnesia into a carbonate, which would be carried in solution to favorable situations and there precipitated.

[28.5.12.]

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## REEF MINING, NEAR LOVEY'S LEAD, MARONG GOLD-FIELD.

*By H. S. Whitelaw, Field Geologist.*

The mining lease dealt with in this report consists of portions of allotments 5 and 6, section X, in the parish of Marong, $1\frac{3}{4}$ miles west of the township of Marong, and 10 miles west of the city of Bendigo.

The surface of the lease consists of alluvial deposits of sand and clay covering Ordovician slates and sandstones, which form the bed-rock of the surrounding region. Auriferous gullies trend generally westward towards the Berry-Moolort-Loddon deep-lead system. While working the gravels in one of these gutters, known as Lovey's lead, auriferous reef-quartz, *in situ*, was discovered at 100 feet below the surface and 200 feet north-east of the south-west angle of allotment 6. At this spot a winze sunk 18 feet on the quartz shows the reef to be between 2 feet and 3 feet wide, dipping about 65° E., with no suggestion of walls. For a depth of 15 feet fair gold was obtained. From the bottom of this winze, No. 1 intermediate level was driven along the reef-channel for about 23 feet, the last 15 feet being in payable quartz between fairly firm walls 2 ft. 6 in. apart. From the end of this level No. 2 winze was sunk 20 feet, the reef to within 2 or 3 feet of the bottom maintaining its width, dip and value, but presenting a somewhat rubbly appearance, due to a series of small faults which fracture it. From the bottom, which is in poor quartz, No. 2 intermediate level was driven southward 35 feet to a fault, and to the end of the payable gold. These workings show the shoot to be about 20 feet in length, measured horizontally, and to pitch to the southward (S. 20° E.) at an angle of about 30° ; measured along the pitch it is 60 feet in length.

In all 205 tons of quartz have been crushed for yields aggregating 113 oz. 12 dwt. of gold, equal to 11 dwt. 2 gr. per ton ; the first crushing cleaned up in December, 1909, returned 39 oz. 16 dwt. ; the last in May of this year yielded $11\frac{1}{2}$ oz. from 55 tons, which is barely payable. The working conditions at this stage becoming unfavorable, a new 8 ft. x 3 ft. shaft was sunk. At a depth of 175 feet in this shaft, which is in allotment 5, and 150 feet S.S.E. of the old shaft, a cross-cut has been driven 35 feet eastward, cutting the reef

at 24 feet. Here the formation is 1 foot to 2 feet wide, irregular and unpayable. A level has been driven on it northward 40 feet to the No. 3 winze from the old workings, but the quartz along the whole length was poor. A level has also been driven on it southward 25 feet with no better prospect than was disclosed in the opposite direction, the reef about 3 feet back from the face breaking up into small spurs of uninviting appearance. In the cross-cut at 26 feet east of the shaft, a winze reached water at 16 feet in depth (191 feet below surface). In the bottom of this the reef is also broken and unpayable.

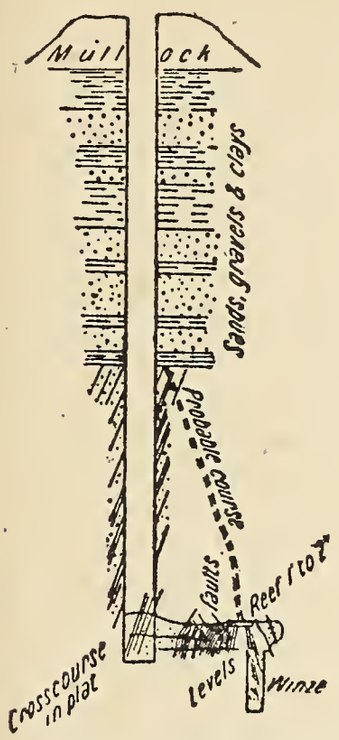


Fig. 21.—Section of Shaft.

Scale, 80 feet to 1 inch.

The south level at this depth was driven with the hope of meeting with a similarly pitching shoot which may exist above the one already worked. From the present shaft, this and the extension of the north level is the only work possible, but the prospects so far as the levels have progressed cannot be said to be encouraging.

The workings of this mine show that the reef is an irregular deposit of quartz on an east-dipping slide, which has cut through and ruptured an anticline. That the rocks of the Marong gold-field have been folded like the beds at Bendigo has long been known, and two anticlines have been located, on Wilson's Hill, a small Ordovician inlier about half-a-mile south-east of Mr. Thomas's lease, where extensive mining operations on spurs and legs have been conducted with generally payable results. So far as can be learned the cap of a saddle reef has not yet been discovered, but that such exists there can be little doubt. Quite recently several leases on this hill and to the westward of it have been granted, and it seems that the locality is about to be given the attention which it deserves. The slates and sandstones by their colour and texture appear to be well down in the auriferous series. Sites for the shafts of the new ventures should be properly selected, and sinking persisted in. On the outskirts of Bendigo there is a greater tendency to drive levels than to continue sinking shafts, and as a consequence many promising shows have been closed down. On the lease in question it is to be hoped that sinking will be proceeded with ; but if this be decided on it will be necessary, or at least advisable, to sink a new shaft larger than the present main one, and on the eastern side of centre country.

[26.7.10.]

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## NOTES ON THE DISTRICT EMBRACING DIAMOND HILL AND ADELAIDE GULLY, CASTLEMAINE.

*By H. S. Whitelaw, Field Geologist.*

The known lines of reefs traversing that portion of the Castlemaine field lying between Castlemaine and Campbell's Creek on the north and south, and the Maryborough railway line and Diamond Hill on the east and west, are in order from east to west the Dan O'Connell, Harvey's Jumble, Bennett's Coolgardie, and Bennett's Western.

The Dan O'Connell shaft, on the Dan O'Connell line, is situated on the east bank of Campbell's Creek, about midway between Castlemaine and Campbell's Creek stations. The reef here was worked with payable results from the surface to a depth of 110 feet, the highest yield being 8 oz. per ton. It strikes N. 13° W., pitches south and dips west. It is said that when water-level was reached and the workings abandoned in the year 1868 payable quartz was dipping underfoot.

On the same line, but about half-a-mile north, is the London shaft, in which no work has been done since 1862. Mr. Wilson, of Castlemaine, who with others worked here, informs me that the reef was a "clay and quartz jumble," which was rich but patchy. One crushing of 2 tons yielded 25 oz. of gold. The pitch is south, and the dip west.

Going south from the Dan O'Connell shaft, the reef does not outcrop, being covered by the Campbell's Creek alluvial deposits, but along the strike of the line specimen gold is said to have been ploughed up in a paddock a few chains south of the shaft. Still further south the line crosses the channel of Campbell's Creek, and in proximity to this spot the Campbell's Creek dredge is said to have obtained its best returns and coarsest gold.

On the western bank of Campbell's Creek, due west from the railway station, dredging operations have laid bare a massive spurry formation in eastern country, known as Harvey's Jumble. Little work has been done on this, and it has not an attractive appearance. The alluvial surrounding it was rich, an enclosing paddock yielding 250 oz. of gold. The gold is said to have been found on the bedrock immediately adjacent to the quartz outcrop, and was coarse, rounded pieces weighing 5 dwt. being common. Some years ago Baker and party received a Government grant of £50 to drive to these spurs from the bottom of an alluvial hole, but the work was not successful.

The three other reefs along which prospecting work has been carried on traverse the spur which divides Campbell's Creek from the tributaries of Muckleford Creek. A dozen or so shafts have been sunk at irregular intervals on these reefs, but only in two or three instances were the prospects encouraging. The best result was obtained from Bennett's Western reef, from which a few loads yielded 18 dwt. per load.

Diamond Hill, due west from the Dan O'Connell shaft, forms part of the spur just mentioned. From all directions it is a conspicuous feature in the landscape. It is capped with Older Pliocene gravels and cement, which have been extensively worked for alluvial gold. It is of a rich red colour, and quite destitute of timber. At a distance it might easily be mistaken for an inlier of "Bendigo" beds, but a close inspection shows that it has derived its colour from deposits of iron leached from the over-lying cement. The surface of the hill, and, in fact, the surface of the whole of the area inspected, is probably high up in the Castlemaine zone. All of the gullies (Boyer's, Specimen, and others unnamed on the eastern side, and Adelaide and Place's on the western side) heading from the Diamond Hill spur are more or less auriferous, the gold being generally coarse (a 3½-dwt. piece found in Boyer's Gully between Coolgardie and Bennett's reefs was shown me by Mr. Stowe, a prospector), but between Bennett's Western reef and Gowar, 2 miles to the west, and Place's Gully and Guildford, 2 miles to the south, the surface rocks are, so far as is known, barren, and apparently above the auriferous zone.

On the reefs occurring within the area in question the Dan O'Connell outcrop is the deepest in the series, but it would seem that even

here deep sinking will be necessary to reach reefs containing shoots of gold in contradistinction to the patches found in the reefs nearer the surface.

No fossils were observed during the inspection.

[19.7.11.]

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## THE SOUTH WATTLE GULLY MINE, CHEWTON.

*By W. Baragwanath, Senior Field Geologist.*

The South Wattle Gully mine is situated 1 mile south of the Chewton railway station, on the eastern side of Wattle Gully. Wattle Gully was famous in the fifties and sixties as an alluvial and quartz-reefing locality. The quartz workings were confined to spurs in broken country, occupying approximately a synclinal fold. On either side of the syncline well-defined anticlines occur, and on the eastern anticlinal fold the present South Wattle Gully mine is located. This anticlinal axial line can be traced from Fryerstown to near the granite contact, a distance of over 10 miles. At varying intervals along this line spurs and bedded reefs have been disclosed, and many payable returns obtained. Specimen Hill, a landmark near the Chewton-Fryerstown road, yielded rich spurs near the centre country at the surface, and a large open cut still marks the attempts of various companies to treat a large width of formation. The records of these companies show the stone to have been of very low grade, and, taken in bulk, unprofitable; though a few individual spurs were rich.

The present main shaft is located on the eastern side of the anticlinal fold, which at this point is remarkable on account of its width, being fully 200 feet from side to side. The shaft is 30 chains north of Specimen Hill, and the anticline between the open cut and the present shaft shows a northerly pitch throughout, varying from 15° to 25°. Work in the main shaft was confined to a bedded formation known as the German saddle, which has been stoped from the outcrop 400 feet south of the shaft to the 228-ft. level in the shaft workings. This bedded reef follows round the anticline, and pitches north from 15° to 35° on the cap. The east and west legs where stoped dip 50° to 60°. From a survey made of the accessible workings in 1902, the reef was found to be from a few inches up to 3 feet in width, and two payable shoots were disclosed and worked to the surface. At the 228-ft. level the reef around the saddle is small, consisting of from 2 to 12 inches of nicely laminated mineralized stone, but it has not proved payable. The east leg varies from 12 to 30 inches in width.

At the 297-ft. level a cross-cut east from the shaft cuts the east leg, on which a drive north has been put in for 200 feet, the leg or back continuing small for the whole distance, although of promising appearance. The extension of this drive north for 100 feet will meet the saddle on its northerly

pitch. This work is deemed advisable, as the saddle at this level may be of sufficient size and value to work. Below this level nothing except shaft-sinking has yet been done. At 420 feet from the surface a plat is being cut. At the 420-ft. level it is advisable to put in a drive southerly along the axial line in order to intersect any formation existing between the shaft and Specimen Hill. On account of the steep northerly pitch, 2 feet of driving will be equivalent to 1 foot of shaft-sinking, and from surface workings sufficient encouragement exists to warrant this work. The German saddle at this depth will lie about 500 feet north from the shaft. It is advisable to continue the north drive at the 297-ft. level around the saddle before driving north at the 420-ft. level.

The zone of the Specimen Hill formation will not be reached in the main shaft until a depth of about 1,000 feet is reached, but before this depth is attained the zone of Shank's reef will be passed. Shank's reef lies about midway between the main shaft and Specimen Hill. Several crushings of payable stone were obtained from it, and to intersect it a former South Wattle Gully company drove a cross-cut east 356 feet to intersect it at 320 feet from surface.

Two small saddle reefs with payable stone on the caps were worked below the German saddle, but have not been seen in the main workings, unless a leg which was passed through in the 297-ft. cross-cut at 30 feet east of the shaft is a part of one of them. A drive south in the centre country at the 228-ft. level should locate the cap of these reefs within 50 feet of driving.

Recently a shoot of stone, which was payable in part, was discovered at the tunnel level, and some stoping was carried on above and below this level. This shoot appears to be identical with one the lower portion of which was worked at the 141-ft. to 195-ft. levels some years ago.

Accompanying the centre country a dyke shows in an open cutting at Specimen Hill, and can be traced throughout the whole of the workings.

[28.10.12.]

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## MAGNESITE AT HEATHCOTE.

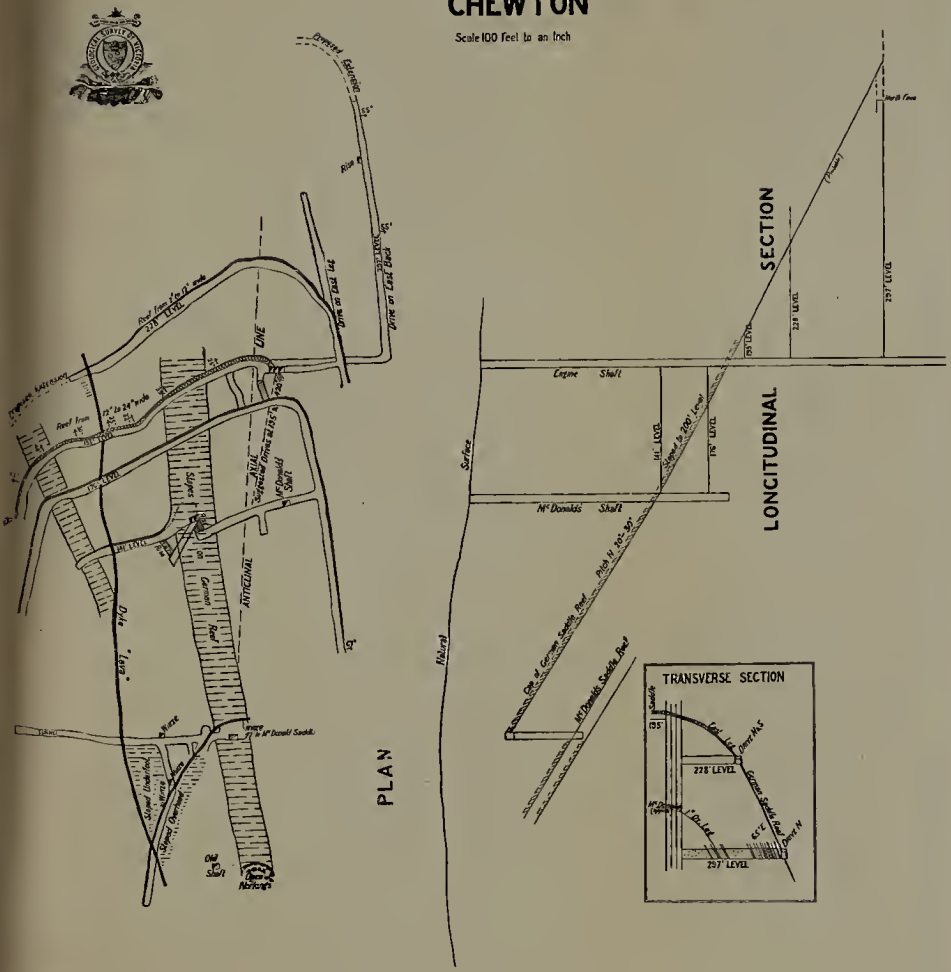
*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

Many years ago an extensive area of ground on the south side of the railway line at Heathcote was sluiced away by the late Hon. J. A. Wallace. Among the pebbles, blocks of ironstone, and pieces of quartz left on the sluiced ground, were fairly numerous concretionary lumps of magnesite, up to 20 or 30 lb. in weight. About four years ago Mr. A. Wolskel inquired about this mineral, and was referred to this locality, and advised to sink along a certain line, with the object of ascertaining what quantities were available below the surface.

Since then prospecting work has been carried out principally on the north side of D. Woods' block C1D, about 1 mile south-east from the Heathcote

# SOUTH WATTLE CULLY MINE
# CHEWTON

Scale 100 feet to an Inch


PLAN
SECTION
LONGITUDINAL
TRANSVERSE SECTION
Surface
Level
Incline
Drive on East Lod
Rise
Cross Cut
Old Shaft
Horizontal
Chewton to 400' Level
Pitch N. 10°- 30°
Mc Donalds Shaft
Mc Donalds Saddle Reef
Mc Donalds Saddle Reef Cross Cut
Old Workings
Mc Donalds Shaft
Mc Donalds Saddle Reef
Cross Cut
Level
Drive on East Lod
Rise
Cross Cut
Level
Incline
Mc Donalds Shaft
Old Workings
Old Shaft
Horizontal
Mc Donalds Saddle Reef
Mc Donalds Saddle Reef Cross Cut
Chewton to 400' Level
Pitch N. 10°- 30°
Mc Donalds Shaft
Surface
Level
Incline
Cross Cut
Level
Mc Donalds Saddle Reef
Cross Cut
Level
Mc Donalds Saddle Reef
Cross Cut
Level
Mc Donalds Saddle Reef

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railway station, and with most successful results, as sufficient magnesite has been disclosed to warrant the inauguration of an industry for its utilization.

Along the north side of the block named, and between it and the railway, which is close by, five shafts have been sunk within a length of 5 chains to depths ranging from 14 to 62 feet. These have all been sunk along the junction of a fine-grained granitic rock on the north side and a rock that has a tendency to alter into serpentine on the south side. The junction of these two rocks continues for three-quarters of a mile in a south-westerly direction, and is well exposed in the large tract of rock that has been bared by sluicing operations. So far as exposed there are veins and nodules of magnesite in the serpentinous rock along its junction with the granitic rock, and also in the decomposed granitic rock for as much as 16 feet away from the junction.

At the shaft-workings there is a thickness of from 1 to 6 feet of magnesite along the junction, besides branch veins running into the decomposed granitic rock. The junction is almost vertical in parts, but more generally it dips at about 80° to the southward. Decomposition of the basic rock on the south side of the junction has supplied the magnesite, which was dissolved out and re-deposited along the junction, along the joints for several feet back from the junction in the granitic rock, and in fissures in the decomposed basic rock itself over wide areas.

In the most north-westerly shaft, which is 62 feet deep, the vein at 32 feet from the surface ranges from 2 to 3 feet wide in the level, besides which there is a considerable amount of magnesite in the branch veins in the granitic rock. In the other shafts the magnesite appears to be continuous along the junction, and also to average quite 2 feet in thickness to a depth of 20 feet.

The vein appeared quite strong, and of average width in the south-eastern shaft, and no doubt continues along the junction in that direction, while in the opposite direction magnesite is well shown as veins and nodules in the basic serpentinous rock. At one place where a little work has been done at the junction some promising material was disclosed, but here it does not appear to attain as great a thickness as in the shaft workings.

Already a very considerable tonnage of excellent magnesite is disclosed in the workings, and there is promise of a large quantity being obtained from this locality.

The magnesite results from the decomposition of the basic rock, and its occurrence in the granitic rock results from the jointed and decomposed condition of that rock, therefore this deposit may be expected to continue as far down as alteration has taken place, but where the rocks are in their normal condition, and not altered, the magnesite will not be found. Further mining is required to ascertain to what depth the mineral continues.

Much of the mineral consists of nodules, which, when broken through, are perfectly white and without any stain of iron. Other portions have a slight reddish colour from the presence of a small quantity of iron oxide, but this is no detriment in many cases.

Magnesite is largely used as lining for steel furnaces and for basic fire-resisting bricks. Roasted and ground finely it makes a strong cement, and is used in this state or mixed with small fragments of wood for making floors, as it has the remarkable quality of adhering to the wood. Owing to its comparative scarcity, the mineral is a valuable one, and many fields for its use are opening up; it is therefore important to have a supply within the

State. An analysis made at the Geological Survey Laboratory of the purer portion gives the following results :—

| | per cent. |
|---|---|
| Magnesia (MgO) .. .. .. .. .. | 48·05 |
| Lime (CaO) .. .. .. .. .. | 0·07 |
| Carbon dioxide<br>Moisture above 110° C } .. .. .. | 51·87 |
| Moisture at 110° C .. .. .. .. | 0·16 |
| Iron and alumina .. .. .. .. .. | 0·14 |
| Phosphorous pentoxide ($P_2O_5$) .. .. .. | nil |
| Chlorine .. .. .. .. .. | trace |
| Sulphates .. .. .. .. .. | nil |
| Insoluble siliceous material .. .. .. | 0·26 |

The magnesia present is equivalent to about 99 per cent. of magnesium carbonate.

[12.1.12.]

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## INFUSORIAL EARTH NEAR MICKLEHAM.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

About 7 miles due west from Donnybrook railway station, and 10 chains east from Deep Creek, on allotment 20, parish of Mickleham, a deposit of infusorial earth occurs that has been worked for a considerable time. It is on the north-west slope of a small outlier of basalt that the tunnels and shallow shafts have been driven and sunk. The deposit is being worked, and 300 or more sacks of the material are stacked on the ground. The material is excellent, being quite white, very porous and light. Although there is 2 feet of this material, scarcely a trace of it is apparent at the outcrop. It thins out to 2 or 3 inches, and at the surface there is scarcely anything in the black soil to show that a bed exists. Probably along the course of the Saltwater and its branches there are numerous deposits, but trenching would be necessary in prospecting for them. They occur generally on a bed of clay below the basalt. Shallow lakelets have apparently formed on the clay, and the diatoms have accumulated until the shallow hollows have become filled with them.

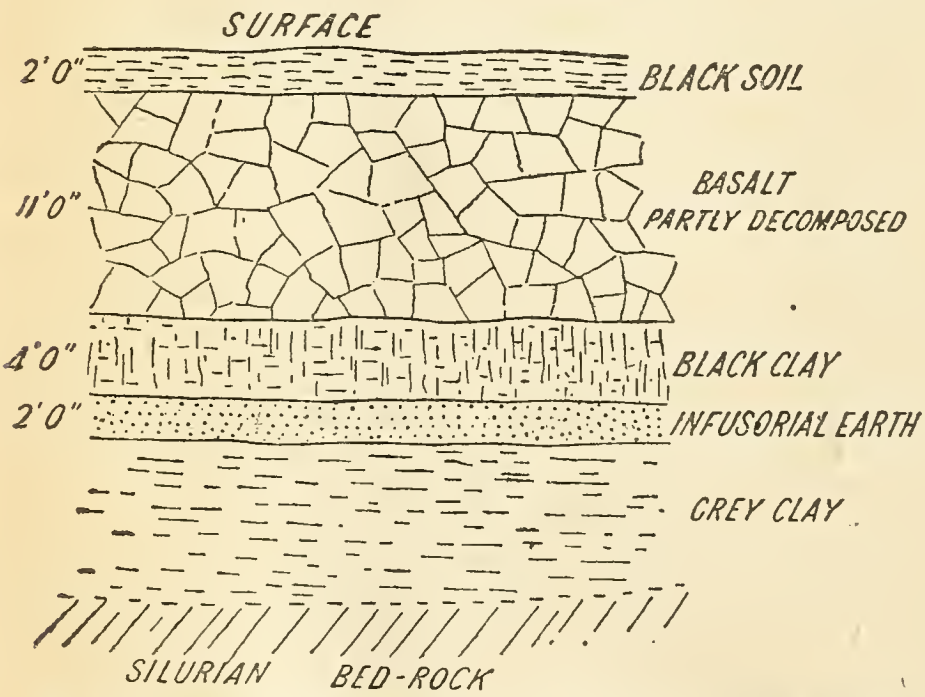


Fig. 22.—Section exposed in one of the shallow shafts. Scale, 16 feet to 1 inch.

Infusorial earth of such good quality has a wide range of utility. The expansion of industries is likely to lead to a greater consumption of this material. There are already many known localities where infusorial earth exists, and systematic search would probably lead to the discovery of many others.[1]

[10.1.12.]

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[1] Diatomaceous Earth and its occurrence in Victoria, D. J. Mahony, Bull. Geol. Surv. Vict. No. 26.

## THE MORNINGTON MARL DEPOSITS.

*By R. A. Keble, Field Assistant.*

Marl deposits of varying thickness are exposed on the shore at Balcombe Bay, 2½ miles south, and at Grice's Creek, 4 miles north of Mornington. Similar deposits are also found along Kackeraboite and Ballark Creeks, 5 and 6 miles north of Mornington respectively.

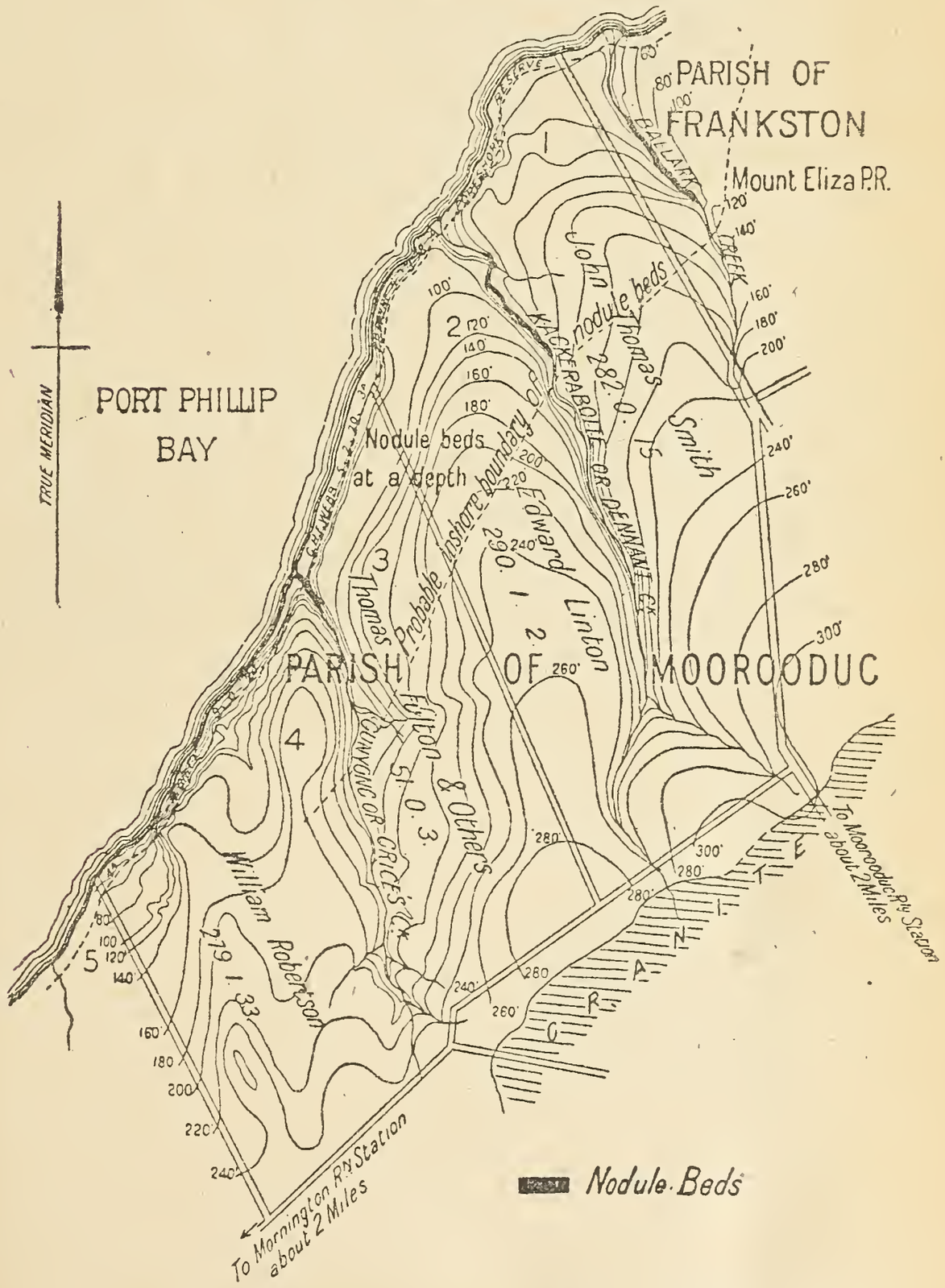


Fig. 23.—Locality Plan of Nodule Beds at Grice's Creek, Mornington.

Scale, 40 chains to 1 inch.

The Balcombe Bay and Grice's Creek exposures represent the denuded escarpment of a minor fault running parallel with the Dandenong-Cape Schanck fault. All the exposures are on the relative upthrow side of this minor fault ;

such as those at Kackeraboite and Ballark Creeks, are due to vertical erosion. Block faulting and slipping make it difficult to work out the several beds.

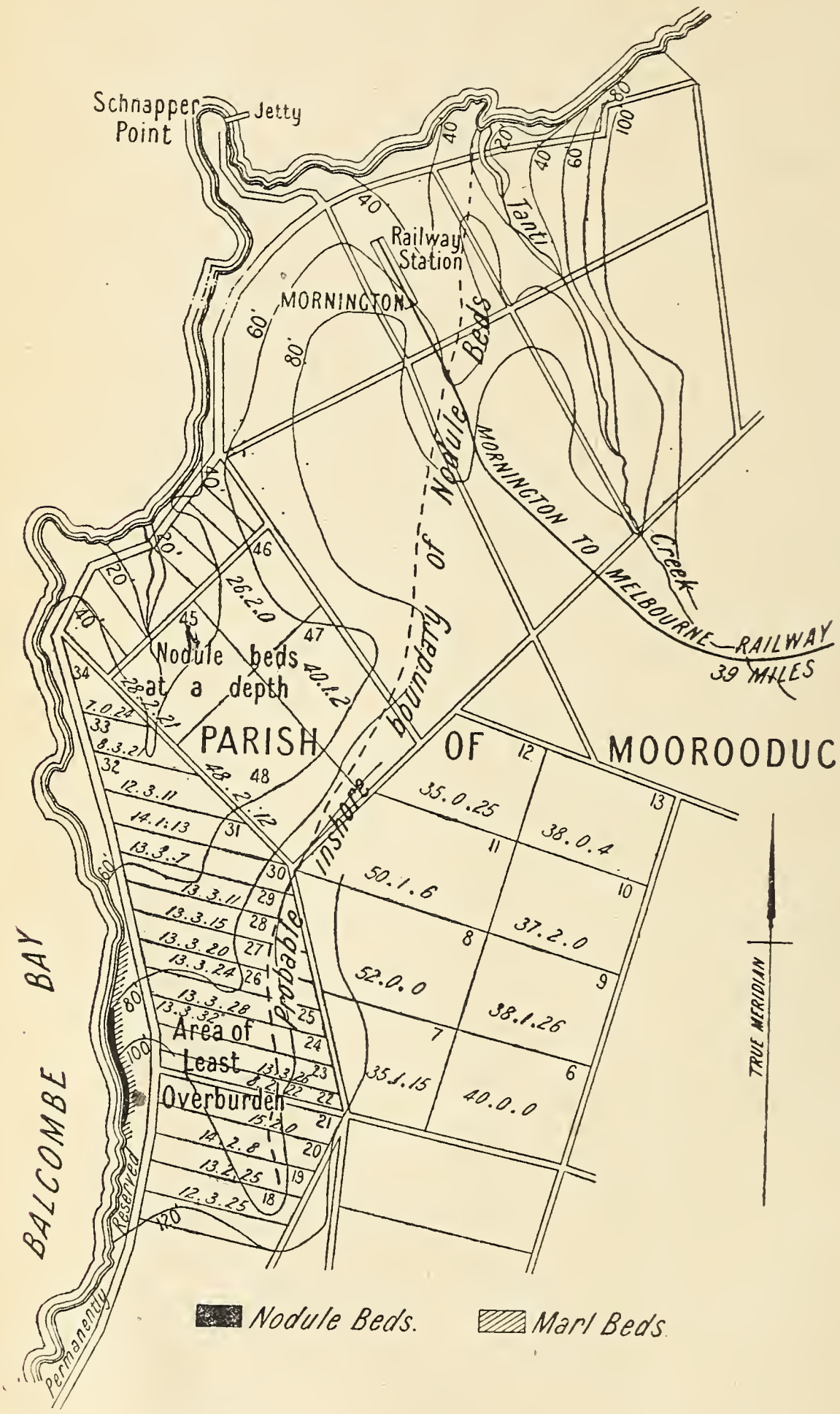


Fig. 24.—Locality Plan of Nodule Beds at Balcombe Bay, Mornington. Scale, 40 chains to 1 inch.

The beds do not extend inland for more than a mile, where they are cut off by the main Dandenong-Cape Schanck fault. They should be found at varying depths over an area of 7 or 8 square miles.

The succession of the deposits from the surface is :—

(*a*) Ferruginous grit and sandstone constituting the overburden.
(*b*) Marl bed containing a few nodules and with crystals of selenite.
(*c*) Nodular beds consisting of septarian nodules in a matrix of marl, grey to blue in colour, plastic when damp, but very hard when exposed to the sun.

This is the type locality of that subdivision of the Tertiary system in Victoria known as Balcombian.

Although important in this instance, it is difficult to give the thickness of the ferruginous grit and sandstone which constitutes the overburden. The landslipped exposure at Mornington shows thicknesses varying between 5 and 40 feet. At Kackeraboite and Ballark Creeks the thickness of the overburden must be considerably over 40 feet.

The thickness of the marl bed varies from 10 to 60 feet. This bed shows only at Balcombe Bay, but it probably exists at the other localities.

The table of analyses gives a comparison of this marl with some used elsewhere in Victoria.[1]

TABLE I.

| — | Marls from Ford's Pit, Mt. Duneed. | | Balcombe Bay, Mornington. |
|---|---|---|---|
| | No. 1. Yellow Marl. | No. 3. Underlying Clay. | Blue Marl. |
| Lime ... ... | 0·60 | 0·32 | 0·36 |
| (= Lime Carbonate) | 1·07 | 0·57 | 0·64 |
| Magnesia ... ... | 1·08 | 0·98 | Small amt. |
| (= Mag. Carbonate) | 2·26 | 2·05 | ... |
| Phosphoric acid ... | ... | ... | Trace |
| Insoluble ... ... | 86·01 | 78·64 | 73·49 |

The nodular bed is dealt with under two headings :—

I. The matrix (marl) containing the nodules.
II. The nodules.

I. A comparison of the marl containing the nodules with some used at other places in Victoria[1] and America[2], and is as follows :—

TABLE II.

| — | Winchester, Maryland, U.S.A. | Marls from Ford's Pit, Mt. Duneed. | | Balcombe Bay, Mornington. | Grice's Creek, Mornington. |
|---|---|---|---|---|---|
| | Greensand Marl. | Sample from 16ft. Face. | White Marl. | Blue to Grey Marl. | Blue to Grey Marl. |
| Lime ... ... | Nil. | 14·08 | 45·78 | 20·77 | 5·33 |
| (= Lime Carbonate ... | ... | 25·12 | 81·75 | 36·97 | 9·48 |
| Magnesia ... | 0·78 | 1·97 | 1·51 | Trace | Trace |
| (= Mag. Carbonate ... | 1·58 | 4·13 | 3·17 | ... | ... |
| Phosphoric Acid... | 0·13 | ... | ... | Trace | Trace |
| Insoluble | 52·30 | 60·61 | 12·17 | 33·24 | 50·37 |

The samples from Mornington were obtained from above the nodular layer. Cosmo Newbery[3] analyzed this marl, and obtained from 1 to 5 per cent. of phosphate of lime, which is equal to about from $\frac{1}{2}$ to $2\frac{1}{4}$ per cent. of phosphoric acid.

1. Agricultural Journal of Victoria, vol. x., p. 10.
2. Maryland Geological Survey (Eocene), p. 53.
3. Prog. Rep. Geol. Surv. Vict., No. ix, Lab. Rep., p. 179.

The practice of incorporating marl or clay with light and blowing sands (such as those at Langwarrin and Carrum) has been in vogue for many years in England and elsewhere. Marling, as it is termed, improves the mechanical condition and practically creates a new soil. Economic transport to the land requiring it, and facilities for cheaply working, are the main factors which operate to determine the utility of such deposits.

The presence of a small amount of phosphoric acid should add to its efficiency as a marl. Millions of tons of a greensand marl from New Jersey, similar to the marls surrounding the nodules at Mornington, have been used as a natural fertilizer. In Table II. the analysis of marl from Maryland, where it is also used, is fairly representative of the New Jersey marl.

"This marl," says Hopkins[1] "contains less than 1 per cent. (18 lbs. per ton) of acid soluble potassium, and but little more calcium and magnesium than could be combined in the phosphates present. Evidently, the fertilizing value is due very largely to its phosphorous content, which amounts to 28·6 lbs. per ton."

The Mornington marl should have at least some value as a "filler." A small percentage of phosphoric acid in material for this purpose should be preferable to a sand with none.

Much of the clay from similar deposits in the eastern States of America is used as a bole or fireclay. Their utility in this direction has not been tested, but such clays should exist at Mornington.

II. The well-known Florida, South Carolina, Russian, and several other phosphates, are either obtained directly or indirectly from nodules or from a few inches of substratum immediately below the nodules. The age of these deposits is Eocene, Oligocene, and Miocene, and they are similar to the deposits at Mornington, Muddy Creek, Waurn Ponds, Altona Bay, and other places in Victoria.

Few, if any, of the nodules at these Victorian localities have been tested for phosphoric acid, and it is possible that valuable deposits of phosphatic marls have been passed over simply because the material obtained for analysis has been taken too far below the nodule beds.

The subjoined table of analyses made at the Geological Survey Laboratory of nodules from Mornington shows them to be poor in phosphoric acid :—

TABLE III.

| — | I. | II. | III. | IV. | V. |
|---|---|---|---|---|---|
| Phos. Acid ... | 0·29 | 1·25 | 1·66 | 0·46 | 0·13 |
| Lime ... ... | 42·40 | 41·40 | 40·57 | 36·66 | 26·60 |
| Magnesia ... | Small amt. | Small amt. | Trace. | Large amt. | Trace |
| Specific gravity ... | n.d. | n.d. | 2·604 | 2·390 | n.d. |

I. Portion of a septarian nodule. II. Nodules from hurricane beach. III. Loose septarian nodules from shore. IV. Septarian nodule. V. Portion of a septarian nodule.

Localities :—I., II., III., and V., Balcombe Bay ; IV., Grice's Creek.

It should be noted, however, that the nodular layers in Florida and elsewhere, giving from 1 to 5 per cent., are frequently associated with layers giving the higher percentages, and that even in the best nodular bed the percentage of phosphoric acid varies within wide limits.

[1] Cyril G. Hopkins. Soil Fertility and Permanent Agriculture, U.S.A., p. 241.

The analyses show one fact of great economic value, namely, that the nodules are concentrates[1], a characteristic in common with those in similar beds in other parts of the world, which give a much higher percentage of phosphoric acid.

Penrose[2] has described eleven varieties of nodules of variable phosphoric acid content, all of which are usually found in association. Probably the whole eleven could be found at Mornington with diligent search.

The percentages of nodule in the talus on the shore varies from 5 to 20 per cent. There is little doubt that, if a layer giving a good percentage of phosphoric acid were discovered, there would be no lack of nodules. The size varies from the size of a pea to 4 feet in greatest diameter. The presence of as much as 2¼ per cent. of phosphoric acid in the marl appears to indicate that nodules giving as much as 5 per cent., or even more, are present, since it is to the nodules that the marls owe most of their phosphoric acid.

The nodules were used in the early days of the State for the manufacture of hydraulic cement. This cement is spoken of by old residents of Mornington as being of excellent quality.

[29.10.12.]

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## NOTES ON FRENCH ISLAND.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

### Coal, Iron Ore, and Clay.

On the south-west corner of French Island, at the head of Westernport Bay, is the township of Tankerton, where some basalt belonging to the Older Basalt series is exposed, and forms a very prominent point. Northward from Tankerton the west coast is sandy, no rocks outcrop, and the sandy soil continues inland as far as Mount Wellington from the northern coast. Mount Wellington is the highest point in the island though it rises only about 275 feet above sea-level.

Various materials from this locality have been assayed or tested at the Geological Survey Laboratory with the following results :—

Assays.

| — | — | Gold. | Silver. | Iron. | Insoluble. | Phospho-rus. | Sulphur. |
|---|---|---|---|---|---|---|---|
| 599 | Ironstone siliceous ... | Trace | Trace | 34·16 | 33·98 | 0·113 | 0·095 |
| 600 | ,, limonite ... | ,, | ,, | 49·64 | 8·93 | 0·220 | 0·103 |
| 601 | ,, siliceous ... | ,, | ,, | 29 86 | 43·01 | 0·350 | 0·051 |
| 602 | ,, limonite and carbonate of iron | ,, | ,, | 41·73 | 8·18 | 0·143 | 0·036 |
| 603 | ,, limonite impure | ,, | ,, | 36·52 | 30·31 | 0·234 | 0·016 |
| 604 | ,, limonite very impure | ,, | ,, | 27·45 | 47 67 | 0·053 | 0.112 |
| 605 | Ferruginous grit ... | ,, | ,, | 26·03 | 49·27 | 0·230 | 0·058 |

No. 602 was smelted and a small ingot of iron obtained.

[1] Cf. analyses of matrix containing nodules, Table II.
[2] R. A. F. Penrose. Deposits of Phosphates of Lime, Geo. Surv., Bull., U.S.A., vol. vii.

## Clay Tests.

| — | Test O. | Test A. | Test B. | Test C. |
|---|---|---|---|---|
| 606 | Shr. 9·5 per cent.<br>Col. light-grey | Shr. 12·5 per cent.<br>Col. light grey | Shr. 20·5 per cent.<br>Col. dirty grey, vitrified | Shr. 22·0 per cent.<br>Col. dirty grey, vitrified |
| 607 | Shr. 8·0 per cent.<br>Col. brown, firm, hard | Shr. 11·0 per cent.<br>Col. red | Shr. 14·5 per cent.<br>Col. black, over-burned | Shr. 14·5 per cent.<br>Col. black, over-burned |

No 606 might have some value for vitrified ware, but shrinkage is large. It is a dirty white clay with a little grit.

No. 607 would be suitable for making common brick. It is a red clay, was tested as a pigment, and found unsuitable for that purpose.

On the north side of Mount Wellington, and about 12 chains from the top, there is an outcrop of limonite (see assay 599). It is a few inches thick, and does not appear to cover any great area, but without trenching and shallow trial pits its extent is uncertain. This limonite may result from the decomposition of the basalt, or it may have segregated from the Tertiary mottled clays that cover so much of the surface of the island.

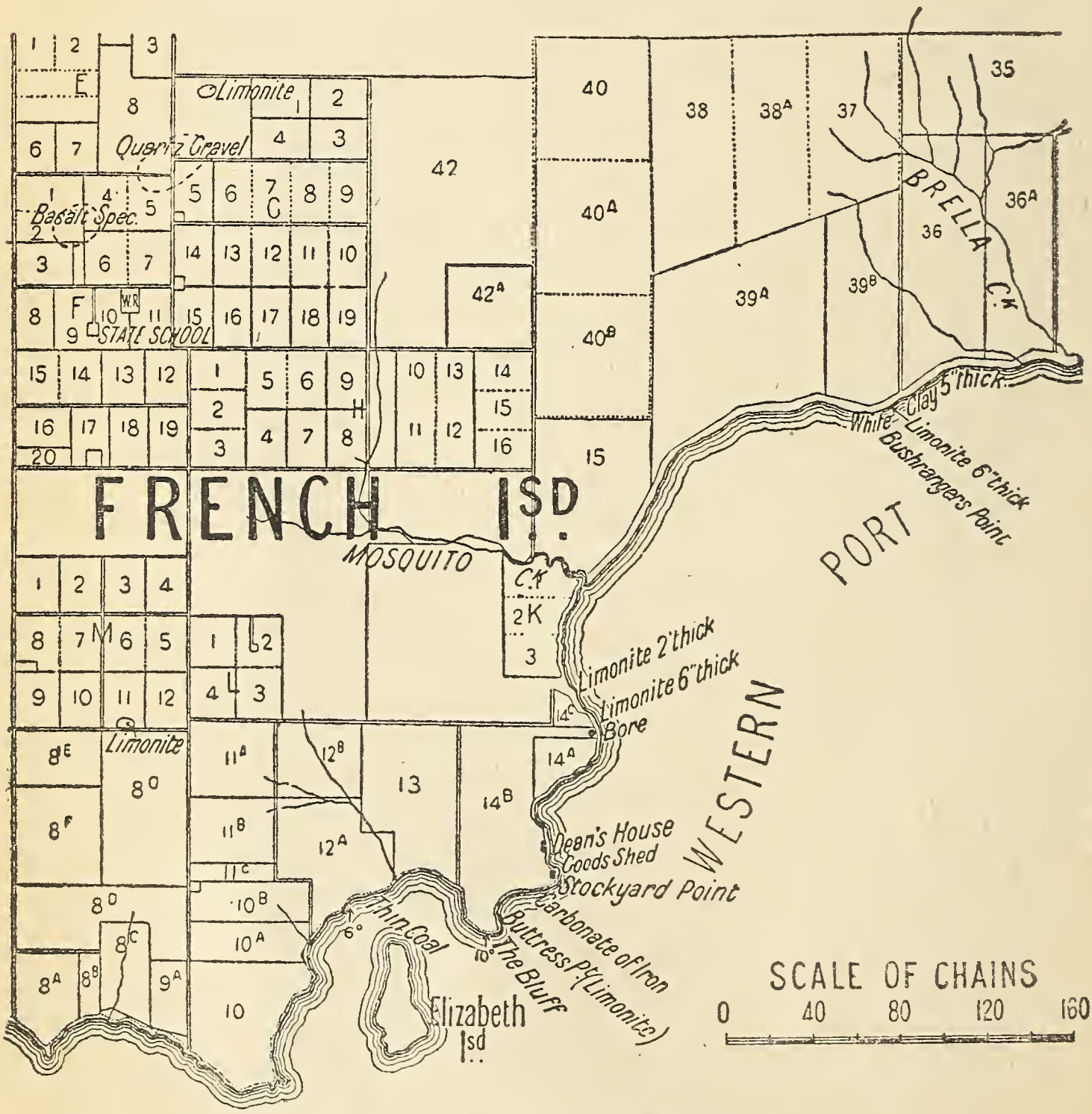


Fig. 25.—Locality Plan of Limonite and other deposits.

South-west 30 chains from Mount Wellington, quartz gravel shows at the surface; it is of late Tertiary age, and probably corresponds in age with the quartz gravels found 1 mile east of Grantville.

Basalt occurs 1 mile south-west from Mount Wellington at Mr. Howard's farm, lot 2, section E. It is a small outcrop of only a few acres in extent, about 120 feet above sea-level. The resultant soil is reddish brown in colour.

Three miles due south is Mr. Harrop's farm, lot 11, section M, where a prominent small hill consisting of the usual red, yellow and grey mottled clay of Tertiary age rises about 120 feet above sea-level. Some limonite (see assay 600) outcrops, but it does not appear to exist in large quantities. The soil southward from Mount Wellington is more clayey in character but of poor quality.

On Major Christopherson's block, allotment 12A, on the south-east portion of the island, at the beach opposite Elizabeth Island, and just below the house, Jurassic rocks are exposed. They are said to extend for about 1 mile southward and eastward, and they outcrop on the beach as far as allotment 14C, section K. A thin seam of coal is traceable for about 2 chains in length just below Major Christopherson's house. The beds of sandstone and shale dip northward at about 6°. The coal is only 1 inch to 2 inches thick, but it indicates that these beds are within the coal-bearing zone. At the Bluff the sandstones and shales dip northerly at 10°, and at Buttress Point (allotment 14B, section N) a little further on some of the beds dip as much as 20° in a northerly direction, but the general dip would be from 10° to 15° northward. Limonite (see assay 601) occurs at Buttress Point.

On the beach half-way between Buttress Point and the goods shed there is an exposure of Jurassic sandstones and shales and above this clay. In this clay there are two or more thin layers of carbonate of iron (see assay 602). The layers are apparently fairly continuous for a distance of 2 chains; the ore is very compact, of high specific gravity, and from 3 to 4 inches thick. A short level has been driven on it just above high-water mark. The ore obtained is said to have been used as ship's ballast.

Further work would determine the value of this deposit, which is certainly the best met with on the island. At Stockyard Point is the goods-shed for storing cargo from the steamers, which are able to discharge within 150 feet of the shore. Basalt occurs on the shore, and a great many basaltic pebbles are scattered on the beach.

About 15 chains north from Mr. Dean's house on allotment 14B, there are two large blocks of basalt on the beach, and some excellent fine clay mottled red and white. This runs along the sea-front of 14A, formerly used for salt works. Along the sea-front of allotment 14C, ironstone (limonite) is exposed at two sites; each is about 1 chain wide, and the southern outcrop (see assay 603) is about 6 inches thick, while the northern outcrop (see assay 604) is up to 2 feet thick. Without some prospecting work the extent of the deposits could not be determined.

North-east from this point, about 2½ miles, is Bushranger's Point, where limonite (see assay 605) is exposed on the beach for a width of about 6 chains and a thickness of 6 inches. There is an exposure of fine white and white and pink clay at high-water mark that is 5 feet thick, and traceable along the beach for about 20 chains. To the westward from this point there are thick beds of mottled red, yellow and grey clays 20 to 30 feet thick of late Tertiary age, and some portions of these beds were tested as pigments, &c. (see clay and pigment tests, 606-7). Similar mottled coarse clays appear to cover a very large portion of the island's surface.

### The Tertiary Beds.

From the general aspect of the Tertiary beds on French Island it may be inferred that they were at no distant date continuous with similar beds on the mainland. Resting on these Tertiary beds, but possibly of Post Pliocene age, are quartz gravels such as occur about ¼ mile south-west from Mount Wellington. This quartz gravel was no doubt laid down when the island was connected with the mainland, and possibly it corresponds with the Post Pliocene gravel on the Divide between Grantville and the Bass River, which possesses some features of special interest. The Grantville and Bass River series consist of well-rounded and polished quartz pebbles, the polishing seemingly due to glacial action. Besides quartz there are pebbles of chert, agate, jasper, silicified wood, &c., also in places many small sapphires. Similar gravel occurs at intervals along the south coast. There can be little doubt that it was deposited contemporaneously with the Post Pliocene glacial action that took place on a large scale in the Lake Dora district, on the west coast of Tasmania, and in the South Island of New Zealand.

If the quartz gravel resting on the Tertiary beds of French Island corresponds with the Post Pliocene gravels on the mainland, it is possible that the island was not detached from the mainland until after this Post Pliocene gravel was laid down, or, in other words, the period at which Westernport Bay was formed is fixed as not older than Post Pliocene, and stretching down to Recent and the present time, for the work is still in progress.

As the quartz gravel must have been laid down under water, it would appear that at that period even French Island and the surrounding country were submerged. Since then there has been an uplift, which has raised the later Tertiary beds and their overlying gravels to heights varying from a few feet up to between 350 and 400 feet above sea-level. This uplift has not been general, however, and it appears to have been compensated for by subsidences in other parts. At Sorrento, on Port Phillip Bay, boring has proved that since the Recent period began considerable subsidence has taken place.

In both Westernport and Port Phillip Bays earth movements resulting in general subsidence have doubtlessly exerted a considerable influence in their formation. Near San Remo, above the beach, north from that locality, there are beds of Jurassic rock that are standing nearly vertically, while on the shore the beds are inclined at a low angle. Erosion, the result of differential earth movements, is accountable partly for these two bays as they now exist. For although the general aspect around the shores of French Island is that of a sinking area, erosion is more accentuated along some portions of the shore than others. That portion of the east coast line between Mosquito and Brella Creeks is being rapidly gnawed away by the sea, and the falling and prostrate trunks of trees along the beach testify to the rapidity with which the land is being encroached upon.

The great subsidence that has taken place at Sorrento within the Recent period is quite sufficient to account for the presence of Bass Strait between Tasmania and the mainland. There is, therefore, no need to place the separation of the island from the continent at a period more remote than the Recent.

[4.19.10.]

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## NOTES ON DOOKIE.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

The greater portion of the parish of Dookie is occupied by rocks of the Heathcote series, principally diabase. The surface is diversified by hills that rise to 750 feet above the general level. A low range runs northward and

southward from allotment 169. Another range, known as the Gentle Annie Range, runs nearly east and west near the centre of the parish, and branches southward for about 2 miles beyond the parish boundary. Half-a-mile north of the township of Dookie is the Saddleback Hill, while $2\frac{1}{2}$ miles a little east of south from the township is the Mount Major Range running nearly east and west. The west knob of Gentle Annie Range rises 600 feet, Mount Major 750 feet, and Mount Saddleback 425 feet above the plain. Dookie railway station is 488 feet above sea-level. Between the hills are wide alluvial valleys and flats, and the great plain of the Murray stretches away to the northward. Highly altered, thin-bedded cherty rocks occur sandwiched among the diabase; they are exposed on the north side of Mount Saddleback in a small gap, also on the north side of the Mount Major Range, on the top of the most western knob of Gentle Annie Range, a few chains east of the cemetery, and at other places. Wherever these sedimentary beds are disclosed they are highly metamorphosed.

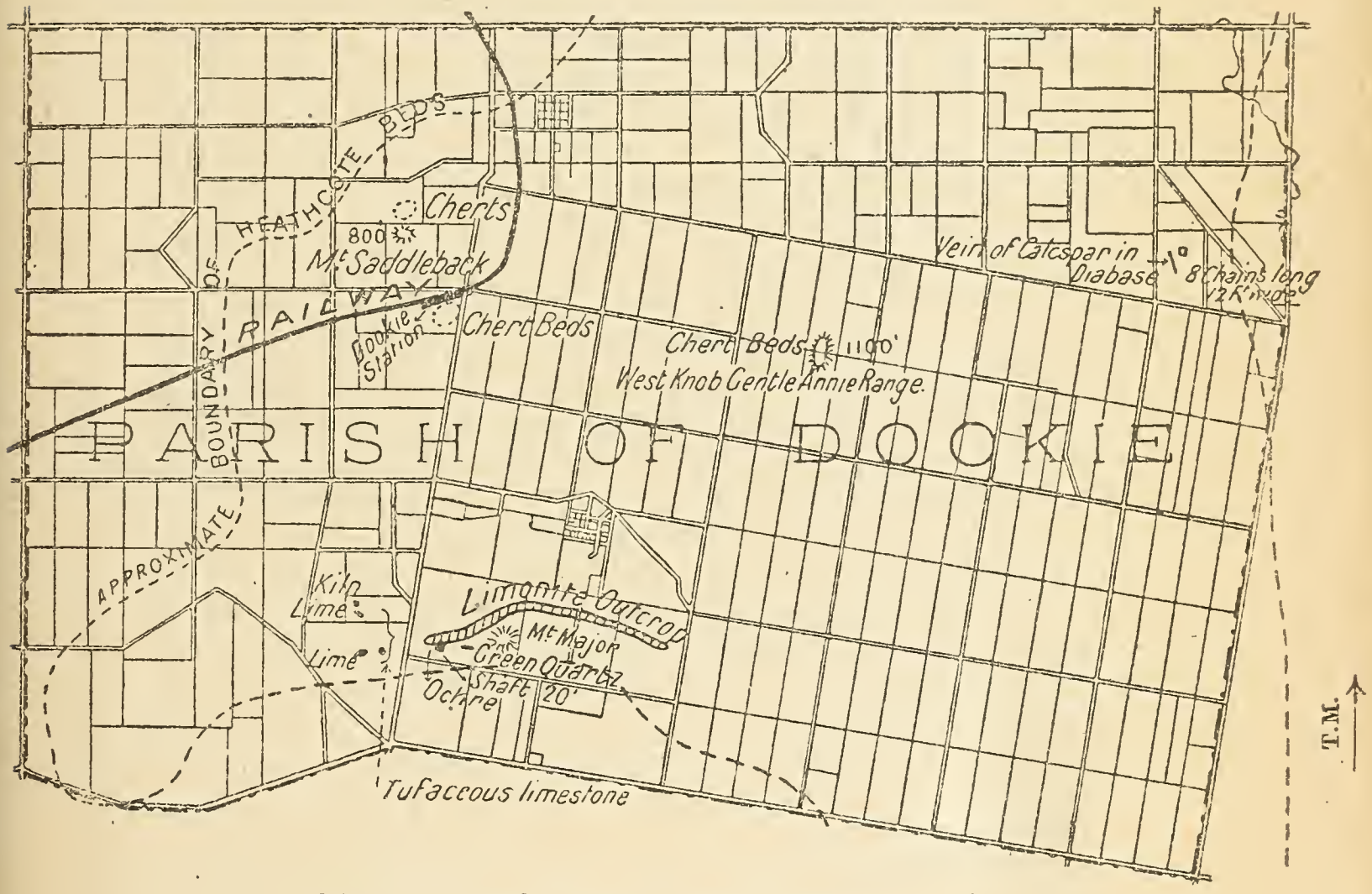


Fig. 26. Locality Plan. Scale, 2 miles to 1 inch.

The soil which results from the decomposition of the varieties of diabase and from the sedimentary rocks ranges through grey, red and black in colour and from loose sandy loams to stiff clays. Its fertility also varies widely.

In allotment 169, which is a reserve in the north-east of the parish, there is a calcite vein about 12 feet wide, traversing diabase rocks. It appears to occupy a fissure, and in parts is thickly studded with fragments of the country rock forming a breccia. The strike of the vein is approximately N. 25° W., and its course is uneven. Portions of the vein are almost pure calcite, and formerly this was burned into lime and sent for long distances. The old kiln is still standing. The vein has been worked in the lowest quarry for a length of about 3 chains, and to a depth of about 10 feet. The floor of the quarry is covered with *debris*, and, consequently, it could not be seen whether the vein continued downwards, but it probably does. There are other quarries

along the course of the vein for about 8 chains. Some of the calcite is well cleaved, showing rhombohedral planes. On analysis, the calcite from the lowest quarry was found to contain 94·1 per cent. carbonate of lime. The soil around the lime kiln is of reddish colour.

On the north side of Mount Saddleback, some calcareous material shows in rabbit-burrows. South of the cemetery, 15 chains inside a small reserve, is a deposit of tufaceous lime that has been worked to a small extent. A small kiln still stands, but the limestone has not been opened out so as to disclose its extent. In any case, it is not a large deposit. About 15 chains south-east of this deposit there are two small openings in tufaceous limestone in allotment 262. The soil derived from diabase appears to be fairly rich in lime.

About 5 chains east of the shaft in allotment 165 there is an outcrop of green quartz that is 1 chain long and 15 feet wide in one part.

Mr. Ferguson states that a deposit of barytes occurs near the top of Mount Major, but this was not examined.

[6.9.11.]

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## Iron Ore at Mount Major.

Running in an easterly and westerly direction past the north side of Mount Major, is a belt of limonite with an irregular course. This belt shows fairly pure limonite in some places for a chain wide, and in parts it appears as a solid mass at the surface.

To test the nature of this deposit, two costeans have been cut across the course of the belt from north to south.

The result has proved that the limonite is more developed at the surface than below, and that at a moderate depth it entirely ceases. The beds consist of thin bands of cherty-looking rock much jointed, with softer beds between that are highly ferruginous, and the limonite has been formed by the replacement of these beds with iron oxide leached out of the very ferruginous beds.

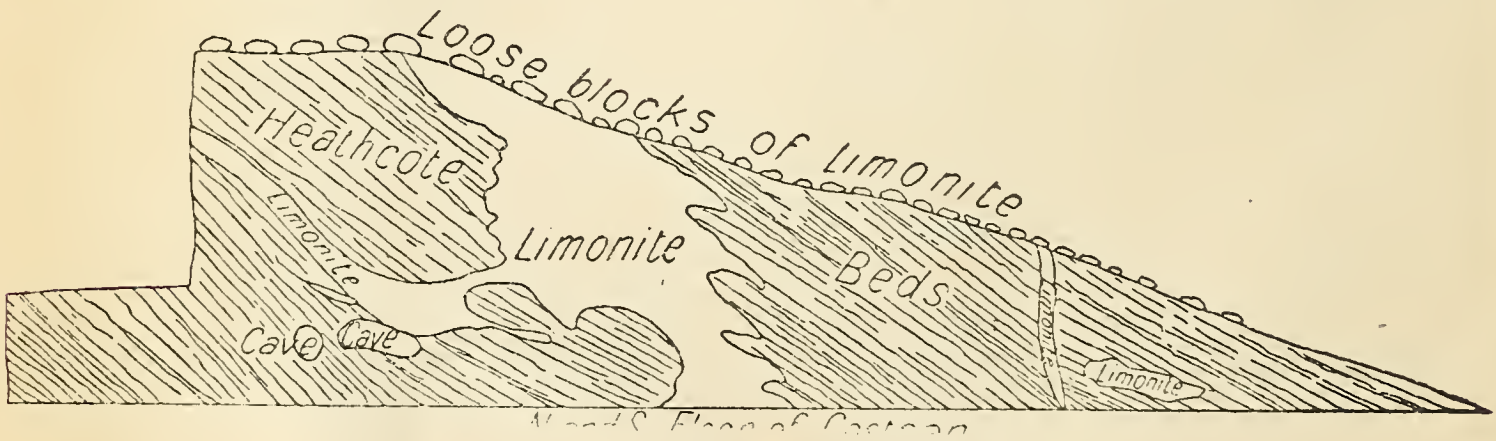


Fig. 27.—Section of No. 1 Costean. Scale, 20 feet to 1 inch.

No. 1 costean is at the head of the gully, in which a spring occurs, and that runs out to the southward of the range. The surface is occupied by large blocks of limonite, and in the gully there is an opening among these blocks that leads into an irregular cave that terminates at the costean. The sides

of the cave are lined with an oxide of manganese incrustation, and on the floor is a deposit of cave dust that may contain interesting remains of the indigenous fauna. Lying on the floor, when discovered, were the skeletons of several foxes. The costean has been excavated to a depth of 21 feet at the deepest part, and the floor of the excavation is all on Heathcote rocks, except for a width of about 8 feet in the centre of the costean, where limonite still goes down. Probably a few feet more in depth would cut this out also.

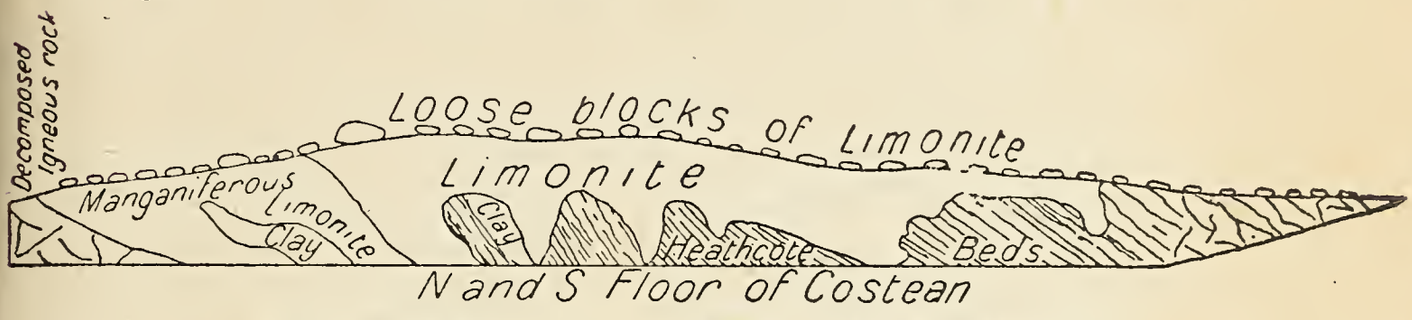


Fig. 28.—Section of No. 2 Costean. Scale, 20 feet to 1 inch.

In No. 2 costean, at the surface limonite is exposed for a width of over 70 feet; but at a depth of less than 10 feet, in the floor of the costean, tongues of the limonite ore are showing that together only amount to 19 feet along the line of section.

Iron ore has replaced the stratified rocks by metasomatic action, and this is the result of atmospheric influences; consequently, the ore has accumulated only at and near the surface.

There are some thousands of tons of limonite at the surface that could be quarried out, but it does not extend downwards. It is not a lode of the usual character, but merely the exposed edges of certain very ferruginous beds that have been altered into limonite and manganese ore by replacement.

Assays of the limonite made at the Geological Survey Laboratory are as follows:—

| | Per cent. |
|---|---|
| From No. 1 costean— | |
| No. 13.—Iron .. .. .. .. | 47·87 |
| No. 45.—Iron .. .. .. .. | 46·23 |
| No. 59.—Iron .. .. .. .. | 47·24 |
| No. 149.—Iron .. .. .. .. | 39·28 |
| Manganese .. .. .. | 12·42 |
| From No. 2 costean— | |
| No. 14.—Iron .. .. .. .. | 45·92 |
| No. 46.—Iron .. .. .. .. | 48·75 |
| No. 60.—Iron .. .. .. .. | 35·32 |
| No. 150.—Iron .. .. .. .. | 36·03 |
| Manganese .. .. .. | 16·76 |

A sample of greenish clayey material (chloropal) from No. 1 costean gave on partial analysis:—

| | Per cent. |
|---|---|
| Silica .. .. .. .. | 47·8 |
| Iron and alumina .. .. .. | 30·7 |
| Lime .. .. .. .. .. | nil |
| Magnesia .. .. .. .. | 1·3 |
| Water .. .. .. .. | 19·0 |
| | 98·8 |

## MINES AT TALLANGALOOK AND BONNIE DOON.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

### The Golden Mountain Mine, Tallangalook.

Tallangalook is about 9 miles in a direction a little east of north from Bonnie Doon railway station and town, and the mine is just south of the township site. The house of the mine manager is, by aneroid, 2,575 feet above sea-level. Close to the house is the boundary between the granite and Silurian rocks.

Mining operations have been carried on in altered Silurian beds at no great distance from the granite. In fact, it appears probable that the presence of gold disseminated through the Silurian rocks is directly due to the intrusion of the granite. One effect of the intrusion of the granite has been greatly to indurate some of the beds—intensely hard rocks outcropping close to Woolf's battery, $\frac{1}{4}$ of a mile below the battery on the mine; another effect has been the mineralization of certain beds, as in the case of the lower tunnel of this mine, where the indurated rock is thickly impregnated with iron pyrites, and more sparingly with arsenical pyrites. Since these sedimentary beds were altered by the granite, the upper portions have undergone further alteration due to oxidation, and the result has been the re-softening of the beds to depths of 100 feet and more from the surface; consequently, much of this rock could be picked down in its present condition. The Silurian beds near the granite, as a result of the alterations, show abundance of secondary mica, more especially in the joints and fissures. Thin veins of granite material appear also to have been forced through the rock mass in all directions. Some granite veins up to 4 inches thick also traverse the sedimentary beds. In the No. 3. quarry, such a dyke dipping south-west at an angle of 25° is traceable for a considerable distance. Such dykes are called "floors" by the local miners. From the decomposed Silurian beds a dark-red soil results, that ranges from 2 to 4 feet thick. Quartz veins are rarely seen in these altered sediments, and they are not apparently payably auriferous where they do occur. The gold is found in a finely-divided condition disseminated throughout the rock mass through a thickness vertically of from 300 to 400 feet as proved by the workings, but to what depth below the workings is unknown. The lateral extension of the gold is also unknown, but judging from its presence at the sites worked on this mine, and in trial pits at some distance from the actual workings, also at Woolf's mine, $\frac{1}{4}$ of a mile east, it would appear that a very considerable bulk of the country rock contains fine gold in small quantities.

From the manager's house a gully runs easterly, and on this gully, 250 feet below the house, is the stamp battery and patent amalgamator, the former driven by steam, the latter by a Pelton wheel. This gully falls rapidly, and a few hundred yards lower down joins the Tallangalook Creek. At about 400 feet below the Golden Mountain battery is Woolf's battery. Just above the junction of the gully and the creek there is a waterfall of over 100 feet in height, which marks the junction of the granite and Silurian beds. If work on an extensive scale were undertaken, a site on the creek would possess many advantages over the present site of the battery. About 15 chains south of the manager's house the ridge rises into a hill called Vinegar Hill, and much of the bulk of this hill is also said to carry a little fine gold.

The occurrence of gold throughout the country rock, as in this case, is not common in Victoria. Something similar in character is found, and has been worked at Wonga, near Stawell.

The attempts to work this deposit date back to the early periods of mining, and several companies have been formed and have failed. This is not remarkable considering the crude methods adopted for saving the gold, which cannot possibly be secured by the ordinary stamp batteries. The degree of economy that has been attained in cyaniding, and the low cost at which the process can be worked, point to this method as being most suitable for the class of ore under consideration.

The mining hitherto done has been on the eastern slope of the hill below the manager's house, and the material has been bodily removed from three open quarries on the hillside. Besides the material removed from these, a considerable quantity of the rock has been stoped underground.

No. 1, or the lowest quarry, is about 200 feet long in a north and south direction, from 60 to 90 feet wide at the top, 30 feet wide at the bottom, and from 80 feet to 100 feet deep. This has been worked down to the level of the lower tunnel, which runs out to the hoppers of the battery, and like the other quarries the whole of the rock has been bodily removed and treated.

No. 2 is a small quarry a little higher up the hill and between the two larger quarries. It is about 66 feet long, 33 feet wide and 60 feet deep. It communicates with the lower tunnel.

No. 3, or the top quarry, is the highest up the hill. It is about 200 feet long; from 33 feet to 140 feet wide at the top, and from 40 feet to 80 feet deep. The whole of the material removed from these open quarries was oxidized and soft, and therefore easily broken down, but in the lower tunnel the unoxidized rock is present, and this would require explosives. The strike of the Silurian beds in No. 1 quarry is east and west, and the dip is 70° north. The strike of these beds at No. 3 quarry is E. 20° N., dip vertical. The general strike where not influenced by intrusions is a few degrees west of north, so that the granite in this case has materially interfered with the strike of the sedimentary beds.

Although so much mining has been done, and such a great quantity of ore has been dealt with, no reliable statistics are avaliable for estimating the auriferous value of the rock. Even where the quantity of gold saved has been recorded, the quantity lost has not been ascertained, and that must have been proportionately great in view of the primitive methods adopted. There are such extensive faces now open that very accurate sampling of the bulk could be done, and this is the first step needed. Trial pits are also required to ascertain how much of this country contains gold and could be worked at a profit. It is almost certain that a very low-grade proposition could be made to pay here if systematically handled in a large way with cyanide. A battery placed in Hell's Hole Creek could be driven by water power, but if fuel should be required there is a splendid forest all round. Unless the rock could be taken from a face and worked on the open-cut principle it might not pay, but this method of work is feasible. Cyaniding under favorable conditions now costs less than 2s. per ton, and if this rock yielded anything like 2 dwt. of gold or upwards per ton, it should prove a workable mine.

[30.9.10.]

### Woolf's Mine, Tallangalook.

About a quarter of a mile eastward from the Golden Mountain battery, and on Tallangalook Creek, a battery of ten heads of light stamps has been placed. The quarry from which the rock was obtained to feed this battery is situate on the north bank, 4 chains higher up the creek. This site is about

1,925 feet above sea-level. The quarry is 100 feet long, 60 feet wide, and from 20 to 40 feet deep. The rock is altered Silurian not far from its junction with the granite. It was broken down in a face and sent away bodily through a pass and by a tramway to the battery. The results are said to have been profitable, but as the ordinary amalgamation process alone was used to save the gold there must have been much loss.

Just opposite the battery on the south side of the creek is a quarry, opened up and worked by Mr. F. Falks. It is about 100 feet long and from 5 to 20 feet deep, and is said to have been payable. The ore consists of the country rock, which has been altered by the granite. Some portions of this rock have been altered to extremely hard, nearly black hornfels. The auriferous rock is about the same distance from the granite boundary as it is from the quarries on the Golden Mountain Mine.

### Tallangalook Sluicing Claim.

About half-a-mile north of the township site a sluicing claim is at work in the bed of the Tallangalook Creek. The height is about 2,500 feet above sea-level. It has been at work for many years, but the old gutter has only lately been reached. The bedrock is decomposed granite of moderately coarse grain; above this is about 1 foot of gravel, the pebbles being quartz, crystallized quartz, tourmaline, &c., very well rounded; above this is drift material and loam, to a thickness of 40 to 50 feet. The gold is very fine, and a little cassiterite and some small completely rounded topazes and garnets are found in the concentrates. This old lead trends past the west side of the township, and probably continues down the valley of Dry Gully, along the course of which are extensive alluvial workings. The age of the lead at the sluicing claim appears to be Newer Pliocene, and on the west side and lower down the valley of Dry Gully there are Tertiary deposits. Dredging operations are being conducted at the lower end of Dry Gully, and there is an extensive deposit of Tertiary age on the west side of the gully opposite the dredge. The road runs over this Tertiary ground, which appears to have been driven out. There is a difference of over 1,600 feet between the level of the Tertiary deposit at the head of Dry Gully and those at the bottom of the gully, near its junction with the Brankeet Creek. Details require to be worked out in this locality.

About half-a-mile east of the railway station, along the main road, there are Tertiary rises skirting the flanks of the Silurian hills and traversing the Junction pre-emptive. The gutter of this Tertiary has been worked to a small extent, and along the main road, even the surface of the gravel has been washed for gold. In the gutter the gold is of high value, and is well rounded. In the gravel are well-worn pebbles of quartz, lydian stone, breccia of black silica, and angular fragments of grey rock. Some jasper and other siliceous rocks are also present as pebbles. The relations between the Tertiary deposits of Dry Gully and this, the Bonnie Doon Tertiary, require to be worked out.

### Bonnie Doon Mine, Bonnie Doon.

About 1 mile east from Bonnie Doon, and on the extreme point of a spur of Silurian rock on the north side of Glen Creek, is the Bonnie Doon mine. The height above sea-level at this point is 925 feet. The beds strike N. 10° W., and dip 70° E. The reef strikes E. 35° N., and dips 85° N.W. It was

discovered by Mr. F. C. Cliff about sixteen years ago. In width the reef ranges from 1 foot to 3 or 4 feet wide, and it cuts through beds of highly indurated sandstone, slate, and conglomerate. Near the reef the conglomerate is intersected by quartz veins, that traverse the pebbles as well as the matrix. This is a case in which pebbles have become veined with quartz after they were well rounded. Pebbles formed of rock through which quartz veins run are common enough in many streams, but pebbles in which quartz veins have formed after the pebbles had been rounded are less frequently met with.

There are direct evidences of metamorphic action in this mine, as the sandstone is altered into hornfels of dark-grey colour, and the conglomerate is highly indurated. At the surface the conglomerate is soft through decomposition. The pebbles in it exhibit much shearing. The alteration in the Silurian beds has no doubt resulted from the presence of granite rock below, as outcrops of that rock occur both to the north and to the south. The conglomerate bed can be traced for miles.

The first crushing from the reef consisted of 20 tons, and it yielded 126½ oz. of gold worth £3 18s. per oz. The shaft is 90 feet deep, and at 80 feet a cross-cut was driven east for 80 feet to the reef. From the surface the shoot was worked to 80 feet and than abandoned, as water-level was reached. On the south side of Glen Creek a shaft has been sunk 70 feet, with the object of picking up the Bonnie Doon reef, but it was not reached.

[19.7.12.]

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## THE LUCKS ALL GOLD MINE, ENOCH'S POINT.

*By O. A. L. Whitelaw, Field Geologist.*

The Lucks All mine is situated at the head of Warner's Gully, in which is a small creek about 1½ miles in length running into the Big River from the western side, about 2 miles south of the township of Enoch's Point. It is reached by pack-horse track, and is about 4 miles from Enoch's Point.

This mine was discovered in 1868 by Mr. Warner, a prospector, while tracing the alluvial gold in the gully to its source. The dyke "bulge" or "basin" is typical of those occurring in the Walhalla, Matlock, Wood's Point, and Gaffney's Creek belt, such as have been worked in the Loch Fyne, Morning Star and Hope, A1, and Star of Erin mines. It differs in one respect, however, in that the dyke occurs in sedimentary rocks of older age than the Walhalla series of rocks; they are probably of Lower Silurian or Ordovician age.

The Lucks All dyke-bulge, which contains the numerous reefs worked, is about 200 feet in width by 700 or 800 feet in length. The strike is N. 48° W., and dip about 65° S.W. The reefs have the usual characteristics of the occurrences in the dyke-bulges; they strike across the dyke between the eastern and western walls, and dip along the length of the dyke. The Lucks All reefs occur one below the other in more rapid succession than those of other local mines, and with one exception fall from the slates at the

northern end of the "bulge" and dip towards the south end at an average angle of about 45°. The exception is Ross's reef, which strikes along the length of the dyke, and dips from the eastern to the western wall at angles ranging between 32° and 50°.

The quartz "floors" or reefs usually consist of 2 or 3 inches of quartz on both hanging and foot-walls, with from 1 to 4 or 5 feet of crushed dyke and quartz between. The following are the main reefs worked at No. 2 level, and between there and the surface, travelling north in No. 2 adit:—

Culverhouse's reef, the first crushing from which yielded 400 oz. from 100 tons of stone.

Phillips' reef was worked along the contact of the dyke and western slates for payable returns.

Sutcliffe's reef was worked for payable returns, and underhand stoped below No. 2 level. The rise from the bottom level (No. 3) is probably on this reef.

Seventy Ounce reef was worked from No. 2 level to the surface for payable returns.

Black reef was stoped from No. 2 level to the surface in stone said to have averaged 1 oz. per ton. It is underhand stoped 8 feet below No. 2 level.

Bodywig's or Banduerg's reef was worked from No. 2 level to the surface; the stone is said to have been very rich.

Burness' reef also was worked from No. 2 level to the surface; the stone is said to have averaged 1 oz. per ton.

Beale's reef is said to have been very rich, and has been worked from 40 feet above No. 2 level to near the surface.

Thousand Ounce reef was rich above No. 2 level, and has been underhand stoped to 25 feet below that level.

No. 2 level then continues for about 80 feet along Ross' reef (the reef with the exceptional strike referred to previously), to the Three Hundred Ounce reef. This averaged about $\frac{1}{2}$ oz. per ton, and has been underhand stoped 30 feet below No. 2 level.

Ross' reef was worked in patches, particularly near the junction, of the Thousand Ounce and Three Hundred Ounce reefs.

Behind the Three Hundred Ounce reef occur the Bill the Blower's reef, Littlewood's reef, the Dynamite, and other reefs, which have been worked for payable returns.

The official returns from the reefs enumerated show over 12,000 oz. of gold obtained, but it is probable that considerably more was obtained than has been recorded.

The lowest adit (No. 3) is 98 feet below No. 2 level, and was driven in recent years for the purpose of cutting the reefs worked in the upper levels and prospecting new occurrences. It was driven 742 feet, and abandoned for want of funds. At 480 feet from the mouth a rise was put up to connect with No. 2 level; this was abandoned for the same reason, and is still unconnected. At 70 feet up this rise, the highest point which could be surveyed, it is distant 45 feet east from No. 2 level. The rise is apparently put up on Sutcliffe's reef. It should be continued about another 20 feet vertical, and a drive then extended west until No. 2 level is intersected.

No prospecting has been done in No. 3 level, but towards the end some promising-looking formations have been cut. One of these at least—that 58 feet back from the face—should have levels driven to both walls of the dyke.

The face of No. 3 level is now in a favorable position for developments, and should be entended until the north end of the dyke-bulge is reached. Each favorable-looking reef intersected should have levels driven to both the east and west walls of the dyke.

The latter portion of No. 3 adit level is on the foot-wall side of Ross' cross-reef, while the greater portion of the gold obtained in the upper levels came from the reefs on the hanging wall side of this reef. The extension of a level north-west on the hanging wall of Ross's Reef would be useful work.

The mine workings are well situated for prospecting and economic development; capital and good management should again place it upon the gold-producing list.

[2.3.12.]

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## THE STAR AND THOMSON GOLD MINE, ABERFELDY.

*By A. M. Howitt, Field Geologist.*

The Star and Thomson gold mine is situated south of Aberfeldy township on the western slope of the Divide between the Thomson and Aberfeldy rivers, and between Barefoot and Lone Star gullies.

The reef occurs in Silurian sandstone and slate, and has been worked for a number of years with varying success by several adits, the two lowest of which are dealt with in this report. A survey was made by Mr. C. M. Lyons, of the Long Tunnel mine, Walhalla, but the plan has not been published.

The upper adit (middle tunnel of Lyons' survey) was driven on a bearing of E. 37° N., and cut the reef at 352 feet. The north drive was put in 560 feet, and the south drive 20 feet. A shoot known as the "Thomson" is reported to have been stoped opposite the adit-level for about 60 feet long by 100 feet to the surface. In the north drive no gold was seen past this shoot, and the reef was irregular in strike, but at 224 feet the reef became more regular, and the quartz more solid, being in places 1 ft. 6 in. wide, with prospects of gold. At 312 feet a cross-cut put in west for a distance of 78 feet shows beds dipping 40° E., but changing to nearly vertical at the end of the cross-cut where a narrow bedded quartz vein is seen striking N. 35° W. As shown in the section of this cross-cut, there is a strong slide dipping to the east and pitching 15° N., which would carry it below the winze. On this slide the beds are bent over on both sides, indicating a movement to the east below it. This easterly movement may have something to do with the main reef being found so much further to the east than was expected in the bottom adit-level north, below and opposite Reilly's winze. Reilly's winze was sunk at a point 87 feet north of the cross-cut as shown on the plan, and Anderson's rise was put up a few feet south of the winze. Another rise known as the "No. 1" is close to the cross-cut.

Reilly's winze has an underlay of 65° E. for 35 feet, but at 51 feet the reef was vertical. A crushing of 4 tons yielded 18 dwt. per ton, but this gold-bearing stone was lost at 15 feet down the winze.

Above the level the reef ranged from vertical to 65° E. for a distance of 15 feet, then 60° E. for another 15 feet, and then the payable stone came in with a westerly dip. From here upwards to the surface, a distance of about 400 feet, the reef has been stoped out, but several blanks occurred where the reef rolled over from east to west, the western dipping portions being payable and fairly large, the eastern dipping poor and narrow. Some

of these rolls are roughly shown on the longitudinal section, as indicated by Mr. Reilly, mine manager; their pitch would be approximately 5° N. to 10° N.

Throughout the mine the reef has averaged 1 foot wide, with bulges of quartz up to 4 feet wide at some places. The quartz is wide and narrow alternately, and consists either of (1) laminated solid quartz with pyrites, payable at times, or of (2) "magpie" quartz with only a little pyrites and more consistently payable. Magpie quartz is quartz with inclusions of slate, &c. At times both of these occur together, one on each wall of the reef channel. The footwall has generally been the richer and more defined. the hanging wall being frequently spurry. The greatest length of the auriferous shoot is said to be 300 feet, and the pitch has been to the south. In this upper tunnel-level the reef consisted of magpie quartz, and the containing strata were slates and sandstones dipping to the east. Some of the yields as recorded by Mr. Hartrick, legal manager for the company, are as follows:—

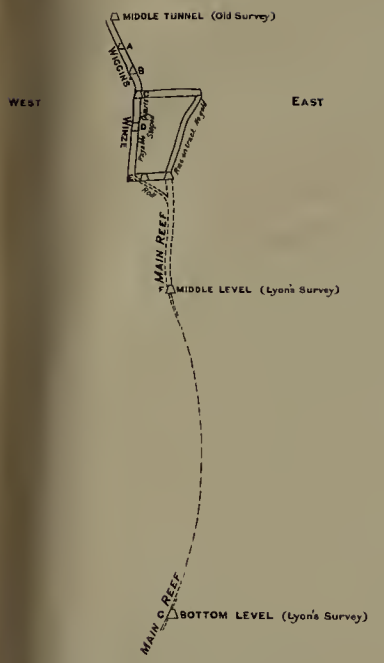
JUNE, 1904, TO NOVEMBER, 1909.

| Date. | Ore crushed. | Gold recovered. | | Remarks. |
|---|---|---|---|---|
| | tons. | oz. | dwt. | |
| 1904—June 25th ... ... | 110 | 49 | 9 | |
| September 12th ... | 109 | 120 | 6 | |
| December 24th ... | 300 | 149 | 12 | |
| 1905—March 27th ... ... | 270 | 84 | 0 | |
| April 24th ... ... | 145 | 67 | 2 | |
| June 27th ... ... | 290 | 59 | 4 | |
| July 5th ... ... | ... | 17 | 6 | From plates. |
| August 12th ... ... | 274 | 62 | 10 | |
| September 14th ... | 70 | 27 | 6 | |
| December 15th ... | 33 | 42 | 3 | |
| December 30th ... | ... | ... | ... | 16 tons 12 cwt. of pyrites sold for £308 10s. 8d. to Edwards and Son. |
| 1906—July 19th ... ... | 40 | 38 | 5 | |
| March 15th ... ... | ... | ... | ... | 2½ tons of pyrites sold for £52 10s. |
| October 8th ... ... | 33 | 30 | 5 | |
| October 19th ... ... | 4 | 3 | 15 | |
| December 19th ... | 32 | 50 | 15 | |
| 1907—April 8th ... ... | 42 | 58 | 15 | |
| April 12th ... ... | 7 | 1 | 1 | |
| ... ... ... | 33 | 30 | 1 | |
| August 13th ... ... | 37 | 28 | 12 | |
| December 14th ... | 50 | 69 | 5 | |
| 1908—May 26th ... ... | 30 | 61 | 12 | |
| September 9th ... | 40 | 94 | 0 | |
| December 15th ... | 48 | 111 | 13 | |
| 1909—June 2nd ... ... | 43 | 58 | 5 | |
| July 12th ... ... | .. | 18 | 12 | |
| November 9th ... ... | 28 | 33 | 3 | |

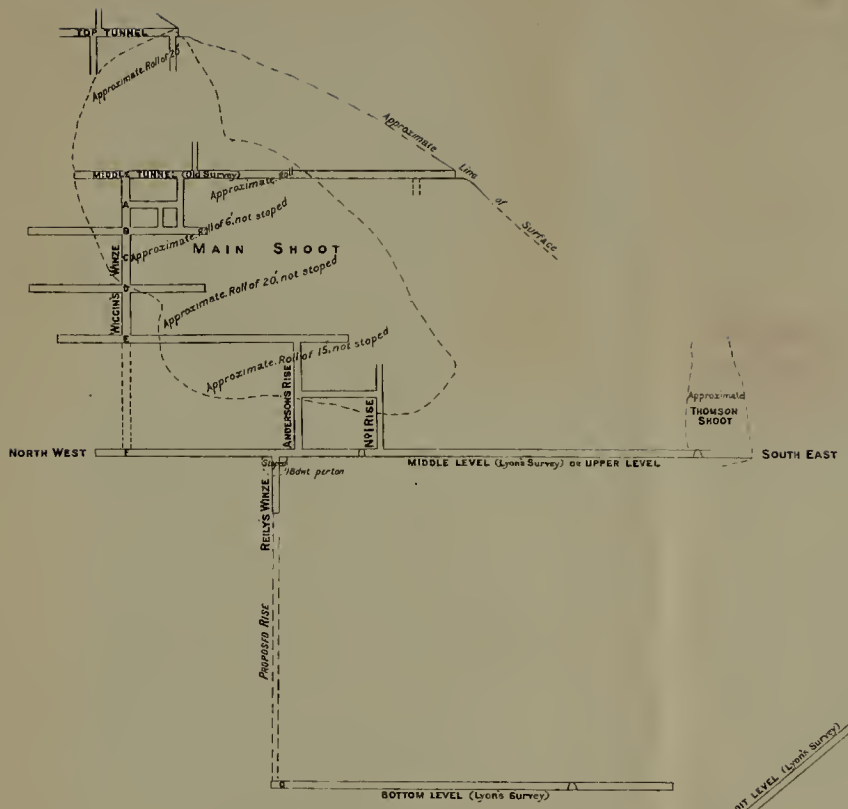
These yields are from the upper adit-workings.

Subsequently the present company was formed, and the main bottom adit driven a distance of 1,054 feet, cutting the main reef at 1,050 feet, and other reefs at 800 feet and 780 feet.

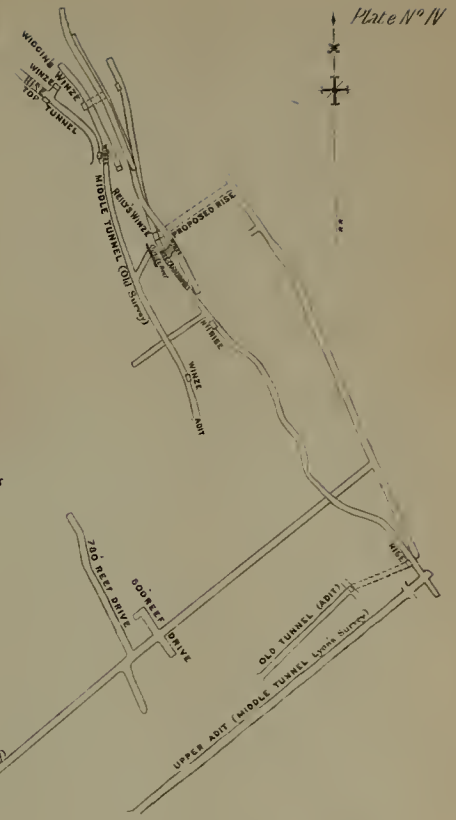
A drive was put in 269 feet north along the main reef, which is here a promising reef dipping 65° W. and having a small make carrying 5 dwt. of gold per ton at 166 feet, but very little solid quartz until 237 feet, where a lot of quartz spurs with pyrites but no gold show for a width of 14 feet.




TRANSVERSE SECTION
at Wiggins Winze.




LONGITUDINAL SECTION
*(With exception of bottom level, information obtained from Company.)*



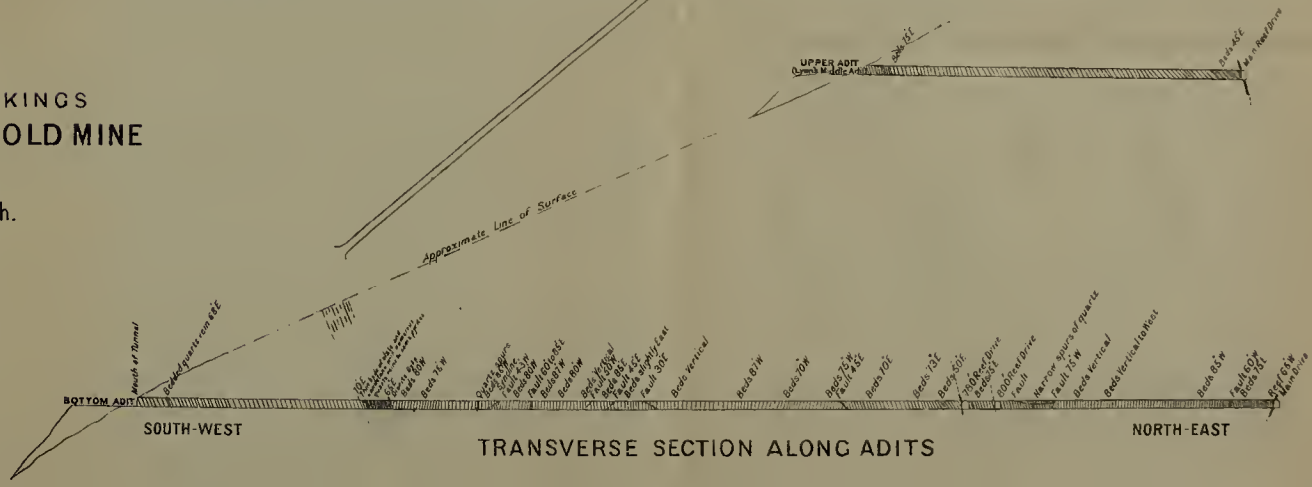

PLAN
*(From information obtained from Company.)*

UNDERGROUND WORKINGS

# STAR & THOMSON GOLD MINE

ABERFELDY

Scale 120 Feet to an Inch.




TRANSVERSE SECTION ALONG ADITS

In the present north face 6 inches of magpie quartz on the hanging wall side dips to the west across the strata. The footwall some feet away to the east carries a few inches of puggy reef. The strike of the reef is N. 21° W. to N. 32° W. The south drive has been put in 96 feet exposing near the adit nice bodies of magpie quartz up to 3 feet wide, and having colours of gold in prospects, but at the present south face, only thread quartz veins and crushed slate are exposed. This south drive was put in to search for the "Thomson" shoot worked in the upper adit level.

At about 800 feet from the mouth of the adit some gold-bearing quartz spurs were followed. They developed into a bedded vein, and were left after a little driving, as the prospects were unfavorable.

At about 780 feet from the adit mouth a reef formation of a promising nature occurred, and was driven on south for 42 feet, the first 20 feet being on a small block 20 feet by 12 feet carrying nice gold. This was risen on, but it cut out at 3 feet above the level, prospects of gold continuing, but no quartz. The south face shows thread veins dipping 75° W. in strata dipping 78° E.

The north level was driven on fairly solid quartz up to 1 foot wide, which expands to 2 feet with spurs at 80 feet in, carrying fair prospects of gold on the hanging wall and footwall, with the central portion barren. The present north face shows more regular veins on a good foot-wall dipping 75° E. in strata dipping 70° E., the difference in dip in the north and south faces being due to a small roll in the reef.

The strata in the main bottom adit are hard sandstones, quartzites, and narrow beds of slate. A large banded quartz and slate formation 27 feet wide and dipping 70° E. was cut at a distance of 228 feet from the mouth of the adit. This quartz formation had a diorite dyke on the hanging wall, but was very poor in gold contents, an assay of pyrites concentrates from it yielding only 2 dwt. per ton.

## General Conclusions.

Beyond the large formation six faults were cut, and at most of them a distinct change in the angle of dip of the beds was noted. Eastern dipping beds predominate, but a wide series of beds ranging in dip from vertical to 70° W. are seen within 100 feet of the 780-ft. reef line.

Between the 780-ft. and 1,050-ft. reefs the beds are more regular, and are not so faulted and disturbed, being on the whole similar to the strata in the upper adit. This bears out the opinion that the 1,050-ft. reef is the main Star and Thomson reef as worked above in the upper adit-levels. Its poverty at the bottom level may be attributed to the reef being driven on in a blank similar to many which have already occurred in this mine on the rolls, the only difference being that usually the blank rolls dip east, whereas this is a western-dipping blank. Better stone may be expected above the roll.

It is evident that between Reilly's winze in the upper workings and the bottom main level there is at least one big roll and possibly several smaller ones.

A rise to connect with Reilly's winze as recommended by the mine manager would be advisable, as the rolls could be more easily followed, and any payable quartz between them proved more quickly than by driving north to catch the rolls on their northern pitch.

The 780-ft. reef is apparently a separate line, and warrants further development north. This reef, on account of its strike and dip should be found a little to the west of the upper adit mouth, the middle tunnel of Lyons' survey. It would probably be found in eastern dipping beds, and would be subject to the usual rolls and blanks. The mine has its own ten-head battery, and is most suitably situated from a mining point of view.

## THE EAST WALHALLA COPPER AND PLATINUM MINE.

*By A. M. Howitt, Field Geologist.*

The East Walhalla Copper and Platinum mine is situated on Leonard's Gully, a tributary of the eastern branch of Stringer's Creek, about half-a-mile from the township of Walhalla in a north-easterly direction.

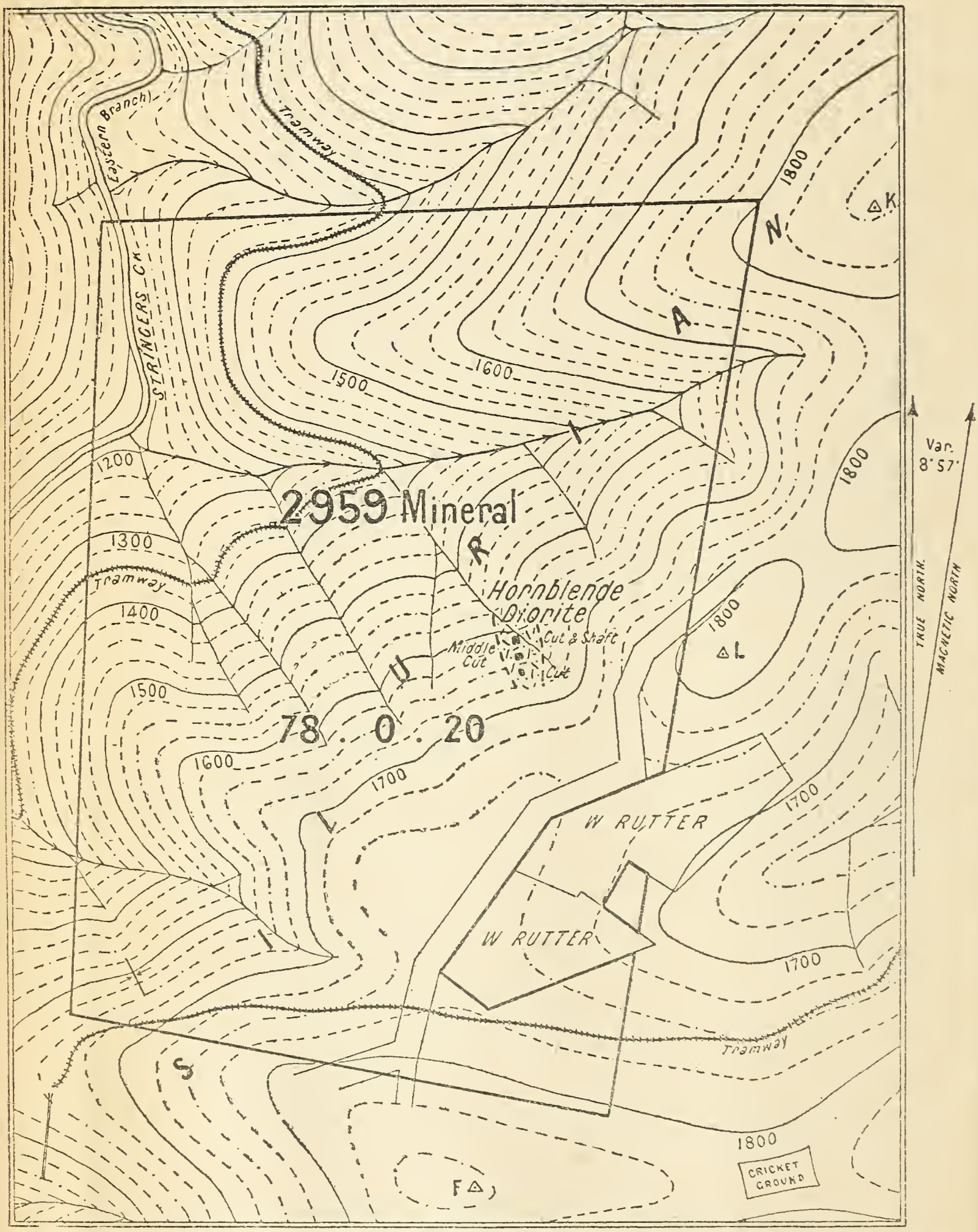



Fig. 29.—Locality Plan of East Walhalla Copper and Platinum Mine. Contours by W. Baragwanath. Scale, 8 chains to 1 inch.

The workings are confined at present to the western side of a large hornblende-diorite outcrop, probably a large boss of about 200 feet by 300 feet,

but its southern and northern limits are obscured by overlying soil and hill detritus, weathered from the surrounding Silurian strata.

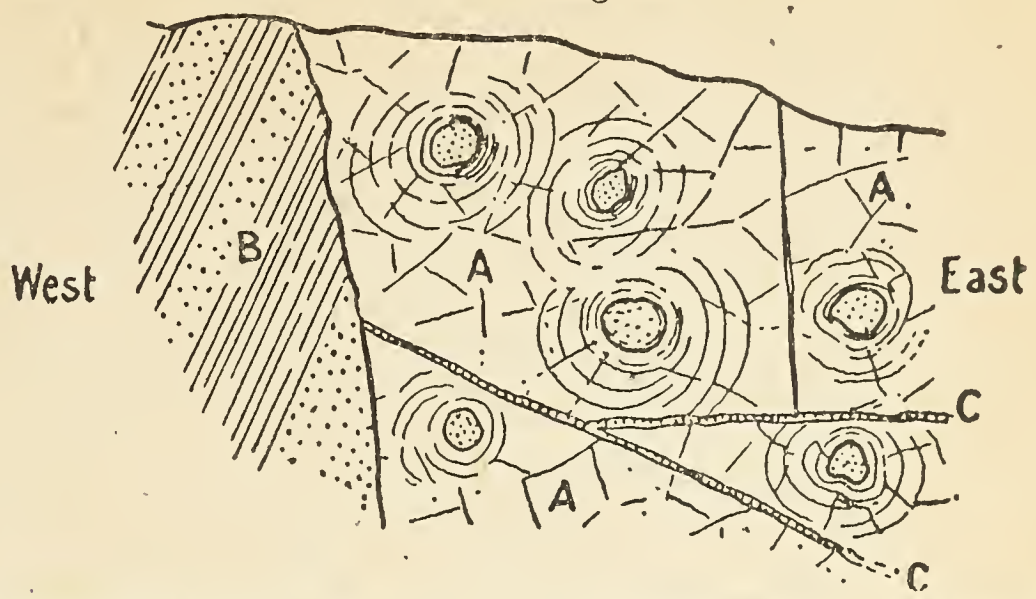



Fig. 30.—Section showing A. Diorite; B. Silurian strata; C. Fault veins. Scale approximately, 8 feet to 1 inch.

The metalliferous portion occurs in the harder kernels in the diorite on the western side of the boss where the hornblende is large and predominant (Fig. 30). The eastern side of the boss is of a much finer character, and

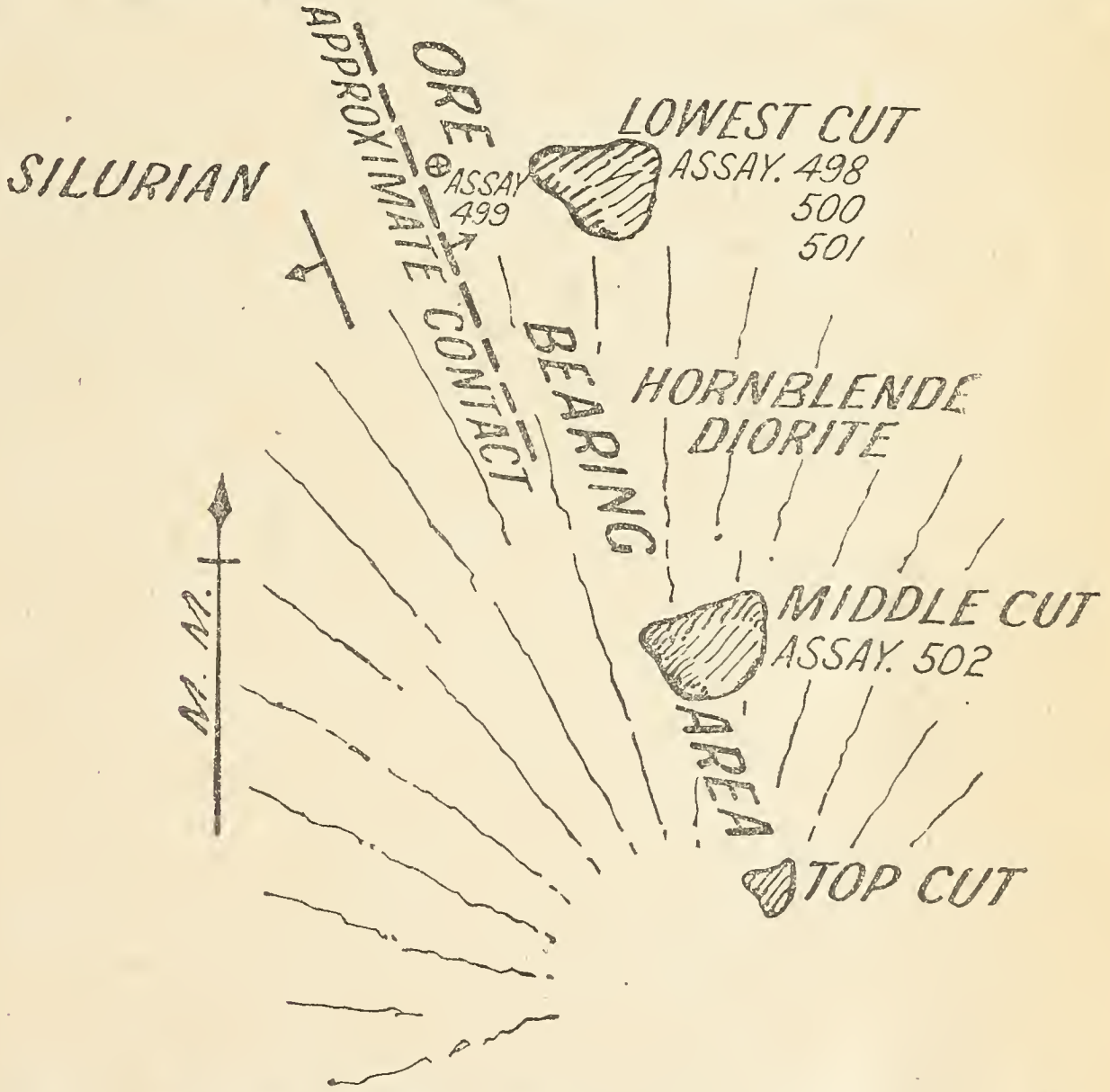



Fig. 31.—Plan showing Position of Three Open Cuts. Scale, 30 feet to 1 inch.

large hornblende is scarce. The hard kernels vary from 1 to 2 feet in diameter, and contain the copper carbonates, azurite and malachite, mostly on the outside of the kernels, with copper pyrites in small crystal aggregations about the centre. The workings have been carried on from three open cuts (Fig. 31), the lowest one having an underlay shaft sunk for 30 feet, with a short drive to the east for a distance of 9 feet. In this shaft a number of ore patches in kernels were passed through, and several slickensided fault veins carrying asbestos and asbestiform quartz.

The ore so far has been confined to the harder kernels, of which there appears to be a regular succession southwards in the underlay shaft (Fig. 32). Between the boulder first found and the underlay shaft is a distance of 20 feet, and in width the ore may extend much further in the hornblende diorite than as yet proved. Ore has been followed on the underlay for 30 feet, and the best assays have come from near the bottom of the shaft. From the lowest workings to the top cut is over 70 feet.

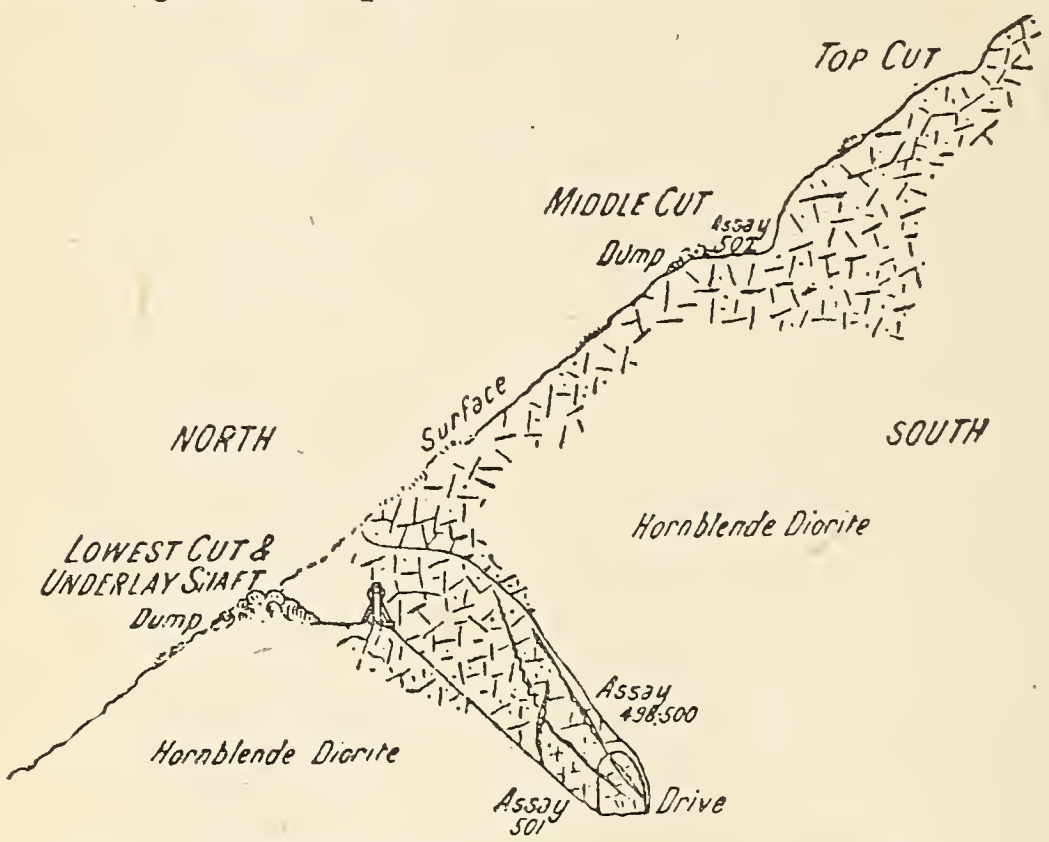



Fig. 32.—Section showing Underlay Shaft and Cuts. Scale, 30 feet to 1 inch.

Several samples of the hornblende diorite from the metalliferous portion of the boss were obtained, and assayed at the Geological Survey laboratory.

| Assay. | Where taken. | Description. | Platinum. | Gold. | Silver. | Copper. |
|---|---|---|---|---|---|---|
| No. | | | Dwt. gr. | Dwt gr. | Dwt. gr. | Percentage. |
| 498 | Seven feet from the bottom of the shaft | Hornblende diorite with carbonate and sulphide ore | 1 22 | 0 16 | 3 10 | 0·60 |
| 499 | Surface boulder | Hornblende diorite with sulphide ore, &c. | 0 4 | 0 4 | 0 20 | 0·17 |
| 500 | Outside shell of a hard kernel near bottom of shaft | Hornblende diorite with carbonate ore | 0 20 | 0 | 2 3 | 0·17 |
| 501 | Bottom level in shaft | Main diorite mass in which the harder kernels occur | 0 3 | Trace | 2 0 | Trace |
| 502 | Middle cut about 30 feet above the lowest cut | Hornblende diorite from the outside shell of an ore kernel, shows carbonates, &c. | 0 4 | Trace | 0 18 | 0·10 |

At present the ore is too scattered in the hornblende-diorite to be of much value, and there is no lode or vein of ore similar to that occurring at the Thomson River Copper and Platinum mine, although the diorite is of a like character. It is possible that by further prospecting an ore vein may be found as a contact vein, or a vein in the metalliferous portion of the diorite. The asbestos is too small to be of value, but larger veins may be found. The assays show that the values of gold, silver, and copper are very low, but the platinum values are more promising.

Further work should be done from the lowest workings, and the western contact between the Silurian strata and the diorite should be prospected opposite the known ore-bearing area to prove whether a contact ore vein occurs.

Later on a boring scheme might be advisable.

[28.9.12.]

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## A POST-TERTIARY FAULT AT BEECHWORTH.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

In the Rocky Mountain Sluicing company's lease, at the upper end of Spring Creek, a remarkable fault is disclosed where the alluvial deposits have been stripped down to the bedrock. The fault cuts through granite, altered Ordovician beds, and Newer Pliocene deposits of clay, gravel, and auriferous wash-dirt. Its strike is N. 40° E., and it dips south-easterly at 45°. The uplift is on the south side of the fault, and it amounts to about 18 to 20 feet vertically, as the same bed of washdirt is about that much higher on the one side of the fault than on the other.

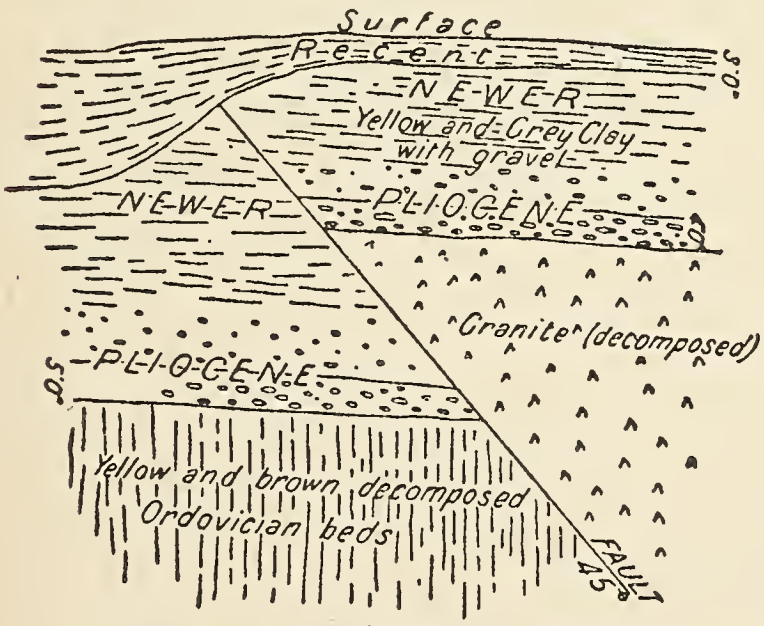


Fig. 33.—Section through Fault.
Scale, 40 feet to 1 inch.

This same fault continues in a westerly direction as far as the Two Mile; how much further is not known. At the Two Mile it is exposed in Collins' old claim, and is traceable for over 1 mile easterly from that site along the course of the old (Newer Pliocene) lead that has been worked on the north side of the Three Mile-road to Pennyweight Flat. The fault runs so persistently along the lead for this distance as to suggest that possibly a fault was followed by the water-course that deposited the auriferous wash-dirt, and that a further movement subsequently cut through the wash-dirt. A section through Collins' claim is shown in a map of Beechworth, prepared by me in 1871, but it was not then known that the fault was the cause of the peculiar conditions shown.

The effect of the faulting at Spring Creek has been remarkable; in one section a hole sunk from the original surface would pass through 20 feet of clays and gravel, then through 4 feet of rich auriferous washdirt, 18 feet of decomposed granite, 4 feet of rich auriferous washdirt, and bottom on altered Ordovician slate and sandstone. This and other sections are shown in the figures. Where the fault passed through the washdirt it was slickensided, but the fault did not sever the pebbles.

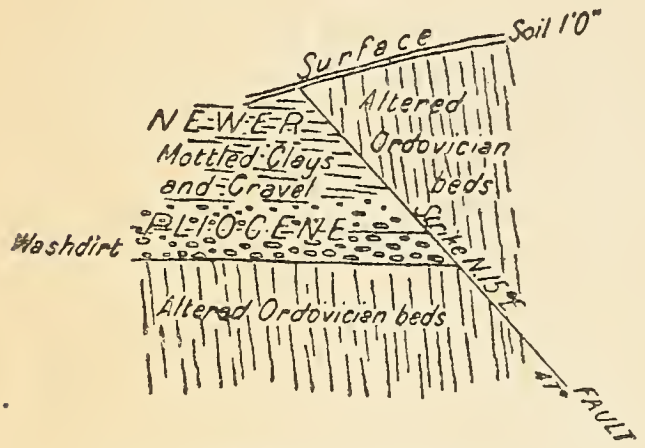


Fig. 34.—Section through Fault. Scale, 40 feet to 1 inch.

There were no surface indications of the displacement caused by the fault, while the Tertiary beds were displaced by it, so that its age must be later than Newer Pliocene and older than the latest Recent; it may have been in the Post Pliocene period or early Recent. A section showing the manner in which the break has been filled in with Recent material would be of great interest, but unfortunately the whole of the surface deposits have been removed by sluicing operations.

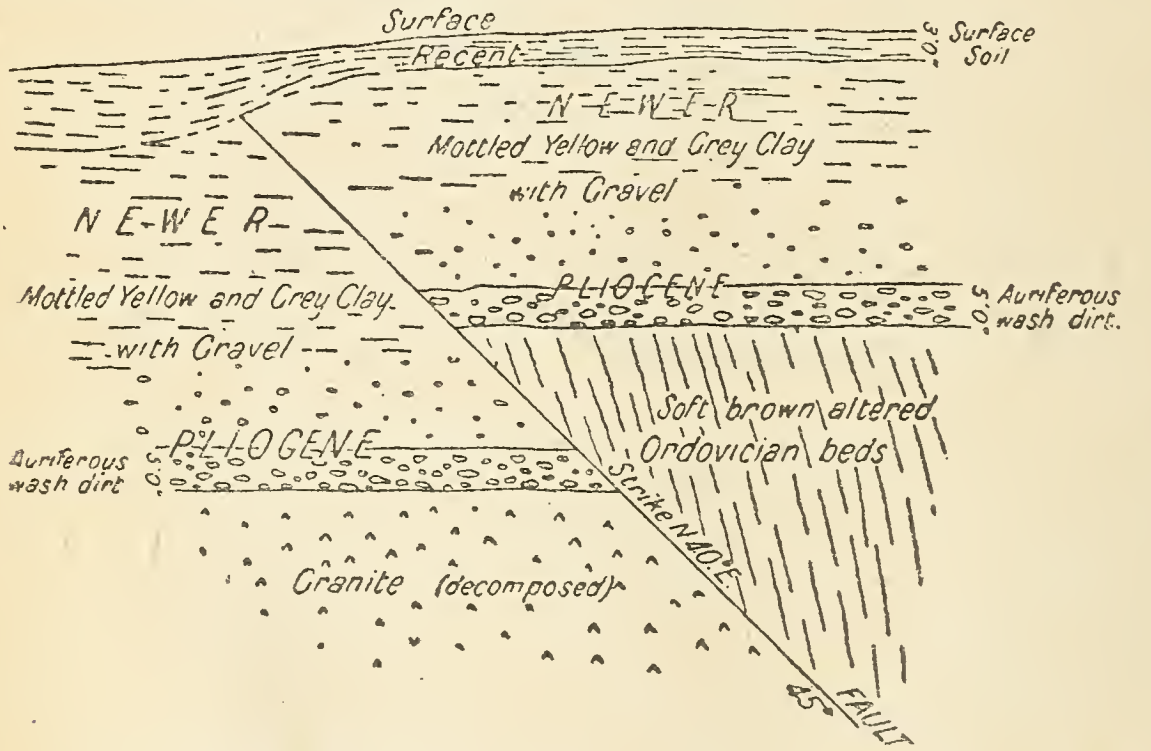


Fig. 35.—Section through Fault. Scale, 40 feet to 1 inch.

In age this fault would probably correspond with those occurring in the Berry lead at Spring Hills and elsewhere, near Allendale, which indicate that fractures of the earth's crust have taken place in comparatively recent times, and even occur down to the present time.

[8.1.12.]

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## ALLUVIAL AND REEF GOLD, BUFFALO RIVER, PARISH OF EURANDELONG.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

On Black Creek, about half a mile above where it runs into the Buffalo River, there are some old alluvial workings where the creek cuts through a deposit of river gravel of Tertiary age, probably Newer Pliocene. The terrace that has been cut through is about 60 feet high on the river face, and a tunnel has been driven eastward for 300 feet under Mr. S. Paul's

paddock, with the object of cutting the continuation of the payable washdirt worked in the Back Creek. The length of this tunnel is, however, not sufficient, as it should be driven about 600 feet. It would be dry ground to work, and as the run of wash in the creek and both north and south of it so far as worked was profitable, the additional driving should be done. The cost would be about 10s. per foot. There is a possible extension of the washdirt southward, or up the river for a mile. If once opened up it could be worked economically, and a little mining would be a boon to the residents, as the ground could be worked in the slack season for farming.

### Paul's Dyke.

A few chains south-east from the south-east corner of allotment 6, section A, parish of Eurandelong, there is a hill which is about 1,030 feet above sea-level. On the top of this hill there is a fault in the Ordovician beds running east and west, and dipping south at 85°. In this fault is a reef of crushed material mixed with quartz about 1 ft. 3 in. wide. On this reef a little work has been done, and a couple of crushings were taken out that are said to have yielded half an ounce of gold per ton. About half a mile south-east from this point is the junction of the Ordovician with the Buffalo granite mass. This appears to be on the western limit of the auriferous belt. If some other reefs were discovered it might be worth while to erect a small plant to crush for them, but they would probably be of low grade.

[24.8.10.]

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## THE MAMMOTH LODE, GIBBO RIVER.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

At a distance of $2\frac{3}{4}$ miles north-eastward from King's, on the Gibbo River, the mining track has cut through and exposed a sulphide lode 12 feet thick. The country rock is slate and sandstone, apparently of Ordovician age. Through this a dyke of quartz porphyry 200 feet thick runs in a northerly and southerly direction. There is evidence of sulphides being present throughout this dyke material, and the rock is stained reddish through oxidation, but the solid sulphide appears to have aggregated near the eastern side of the dyke. Just below the track the river flows at a depth of about 60 feet, and on the south bank the sulphide lode is exposed and is 40 feet wide. Samples were taken from the exposure on the track and also at water-level on the river bank, and these have been assayed. Northward this lode does not appear to have been traced, but southward it is said to crop out at the head of Turnback Creek, and gossan from the outcrop has been shown to me. The gossan is reported as occurring 2 miles south of the mining track. Such a strong dyke is likely to be traceable through the country for a considerable length, and if it runs northward of the Gibbo River it will cut through a mountain over 1,500 feet high. Southward from the river the country rises into high hills, so that there would be good "backs" in this direction. From Benambra a good vehicular road exists as far as King's, and there would be little expense incurred in continuing it to the Mammoth Lode. The Gibbo River is a strong and ever-flowing stream, with rapid current, and it could be utilized for electric power purposes. For economical working the site is excellent. Results of assays made at the Geological Survey laboratory are as follow :—

Gold, from trace to 6 gr. per ton.
Silver, from trace to 6 oz. 17 dwt. 21 gr. per ton (from gossan).
Copper, trace.
Sulphur, 25.4 per cent.

Other assays have given far higher gold results, but as the lode appears to be leached above water-level the true value of the unaltered ore can best be ascertained by drilling. So far as is known, this is by far the largest mineral lode within this State, and should it prove to be worth working it should be a very extensive asset.

[7.6.11.]

### Boring at the Mammoth Lode.

The site of the bores at the Gibbo River is $2\frac{3}{4}$ miles higher up than King's place. Altogether twelve holes were drilled on the south side of the river, the deepest being 142 feet. The holes were so arranged as to give a general idea of the nature and arrangement of the ore-bodies of the lode, which is about 40 feet wide where the drilling was carried out. On Turnback Creek, almost 3 miles south of the Gibbo River, it is fully as wide. The full length of the lode at the surface is unknown. The result of the boring goes to show that ores containing gold, silver, copper, lead and sulphur exist, and that the material between the walls of the lode consists of quartz mixed with sulphides of lead, iron and copper, and a great quantity of porphyry. Distributed through this are bodies of ore that, at any rate in places, are worth up to £10 or £12 per ton. The extent or average value of the material in the lode can only be determined by actual mining operations, as the drill is not suitable for testing the exact value of the contents of the lode.

As the boring proceeded, samples were obtained of the concentrates, and when possible cores were secured for this purpose. The concentrates were taken at every 10 feet, and therefore the results obtained by assaying were for the whole 10 feet, although perhaps only 1 foot of ore was bored through. The assay results in such cases do not show the value of the actual ore passed through, but are the averages of the 10 feet of ore and gangue together.

When cores were obtained the results showed the actual value of the ore. Most of the assays were very poor, but some indicate that ore of good value is to be found in some parts of the lode. Properly to test the extent and value of the ore bodies it will now be necessary to drive a level in the lode a few feet above the river for a few hundred feet, and from this cross-cuts should be driven right across the lode at intervals.

In excavating a position for the machine at the surface on the site of No. 3 bore several cwt. of pyrites carrying up to 7·9 per cent. of copper was broken out. Below the surface at various depths in several of the bores good ore was also found. Below, in tabulated form, are given some results of assays made at the Geological Survey Laboratory :—

| No. of Assay. | No. of Bore. | Depth. | Gold, per ton. | | | Silver, per ton. | | | Copper. |
|---|---|---|---|---|---|---|---|---|---|
| | | | oz. | dwt. | gr. | oz. | dwt. | gr. | Percentage. |
| 315 | 3 | Surface | 0 | 0 | 16 | 3 | 3 | 19 | 6·4 |
| 662 | 3 | do. | | trace | | 3 | 9 | 21 | 7·9 |
| 526 | 2 | 13 to 15ft. | 0 | 6 | 12 | 2 | 7 | 9 | ·102 |
| 534 | 2 | 31 to 34ft. | 0 | 0 | 16 | 5 | 10 | 10 | 1·02 |
| 108 | 9 | 30 to 34ft. | 0 | 0 | 16 | 3 | 13 | 4 | ·51 |
| 114 | 9 | 56 to 62ft. | 0 | 2 | 15 | 0 | 13 | 17 | ·18 |
| 115 | 9 | 63 to 67ft. | 0 | 1 | 7 | 1 | 16 | 14 | ·54 |
| 321 | 10 | 73ft. | | trace | | 50 | 16 | 14 | 11·28 |
| 234 | 10 | 70 to 80ft. | 0 | 1 | 23 | 4 | 18 | 0 | 1·58 |

There was also 33·9% of sulphur in Assay No. 315.

[13.8.12.]

## SILVER LODES, OMEO.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

About 1½ miles at W. 15° south from Omeo, and on the same level are the silver lodes opened up by Mr. G. W. Forsyth on Lightning Creek. The first lode is about 5 chains north-east from the corner of O'Connell's paddock. The country rock is mica-schist, probably of pre-Cambrian age. It is from 3 to 6 inches thick, and, like the other lodes here, strikes north. The lode consists of quartz permeated with fine sulphides of iron, &c. About 100 feet west of this lode is a second vein 10 inches thick that carries silver-lead ore (sulphide). Smaller veins of quartz and sulphide occur between these lodes. About 30 feet west of the 10-inch lode is another of equal thickness; it is in decomposed metamorphic rock. Fifteen feet further west is a lode 1 ft. 6 in. thick, which, Mr. Forsyth states, carries both gold and silver. This lode on the top of the spur junctions with two others that range from 8 to 18 inches thick, and that carry sulphide ore.

About 200 feet further west, on the top of the ridge, is a lode 15 inches thick, and widening to 2 feet thick at the bottom of the hill near Livingstone Creek. This lode carries good looking ore for 200 feet in length. Native silver in small grains occurs in the loam and in the surface stone.

All of these lodes intersect a ridge that rises about 130 feet above Livingstone Creek. They run for about 200 yards in length through metamorphic country. Along the course of Livingstone Creek the rock is principally mica-schist, striking N. 45° W. and dipping south-west.

So far merely surface excavations have been made, but the best method of exploiting the lodes would be by driving along them just above high-water mark.

From the attached list of assays it will be seen that these lodes carry rich ores of silver, and they deserve to be well opened up.

Besides this group of lodes, others are known in the neighbourhood, and if a good mine were established it is probable that many discoveries would follow, for there is an immense area of country favorable for such ores around Omeo. In connexion with the discovery of these silver lodes, it is deserving of notice that the alluvial gold of the Omeo district is remarkable for the proportion of silver in it, which reduces the value in some cases to below £3 per ounce.

Mr. Forsyth, a keen prospector, was looking for gold, and sent samples of the ore to the laboratory for assay, and in this way its value in silver was ascertained.

The following table shows the results of assays made at the Geological Survey Laboratory. The samples were submitted by Mr. Forsyth:—

| No. | Gold, per ton. | | | Silver, per ton. | | |
|---|---|---|---|---|---|---|
| | oz. | dwt. | gr. | oz. | dwt. | gr. |
| 429 | 1 | 0 | 8 | 420 | 0 | 8 |
| 479 | 0 | 17 | 0 | 313 | 6 | 3 |
| 541 | 0 | 6 | 12 | 278 | 1 | 4 |
| 542 | 1 | 18 | 18 | 10 | 14 | 13 |
| 603 | 0 | 3 | 6 | 0 | 19 | 6 |
| 604 | 0 | 4 | 14 | 0 | 14 | 16 |
| 605 | 0 | 2 | 15 | 54 | 16 | 22 |
| 606 | 0 | 3 | 22 | 14 | 18 | 19 |
| 607 | 0 | 1 | 7 | 50 | 12 | 1 |
| 608 | 1 | 5 | 11 | 8 | 10 | 20 |
| 609 | 0 | 2 | 22 | 3 | 5 | 4 |
| 638 | 0 | 2 | 15 | 80 | 0 | 15 |
| 639 | 0 | 16 | 0 | 144 | 16 | 21 |

# SOME IRON ORE DEPOSITS IN SOUTH GIPPSLAND.

*By E. J. Dunn, F.G.S., late Director, Geological Survey.*

## Alberton West.

In the parish of Alberton West an extensive quarry has been worked in basalt. It covers several acres, and the material was used for ballasting the railway. On the cultivated lands around the quarry irregular masses of limonite are ploughed up, and on the west side of the quarry larger blocks exist (see analysis No. 6). The limonite is evidently derived from the decomposition of older basalt. No large deposit was seen. Analyses made at the Geological Survey Laboratory gave results as follows:—

Analyses of Iron Ores.

| — | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Iron (Fe) ... ... | 27·9 | 24·7 | 40·7 | 10·9 | 17·7 | 43·7 | 49·2 |
| Insoluble ... ... | — | — | 7·52 | — | — | 15·93 | 6·76 |
| Phosphorus (P) ... | — | — | 0.21 | — | — | 0·17 | 0·28 |
| Sulphur (S) ... | — | — | Nil. | — | — | 0·031 | 0·091 |
| Gold, per ton ... | trace | trace | 0·1·7 | trace | trace | trace | trace |
| Silver, per ton ... | trace | trace | 0·0·16 | trace | trace | trace | trace |

1. Limonite, San Remo beach.
2. Limonite, Dickie's Point, 1 mile north of San Remo.
3. Ferruginous sandstone, Sandstone Island, Western Port Bay. The iron occurs as carbonate.
4. Bog iron ore (limonite), D. Millar's property, 8 miles north of Inverloch.
5. Pisolitic limonite, D. Millar's property, 8 miles north of Inverloch.
6. Limonite from quarry, Alberton West.
7. Limonite from ½ mile south of Grantville.

## Inverloch.

About 8 miles north-easterly from Inverloch, on David Millar's holding, allotment 25, parish of Leongatha, and 10 chains east from the house, there is an outcrop of bog iron ore that covers several acres of ground on the west side of the creek, and just at the foot of the hills (see assay No. 4). There is nothing to show the depth of the deposit, nor can the limits be defined without trial pits. As the quality is so poor there is no need to prospect for the present.

The origin of this ore is quite obvious, for basalt occurs on the hill where the house stands, and also on the ridge to the north of the iron-stone deposit. The basalt sheet must have been far more extensive at one time, and as it decomposed and weathered away the iron oxide was leached out and was redeposited in the flat as bog iron ore. Near the house, and also about ½ mile south of it on the road, limonite (see assay No. 5) of a more compact character and better quality occurs as irregular pieces. This has also been derived from the older basalt, but there is so little of it that it is of no importance.

## San Remo.

Along the beach to the north of San Remo for about a mile limonite occurs between high and low water-mark, usually as irregular pieces of no great size. It stretches out towards Churchill Island, and is said to occur on the beach there. There is no vein or lode, but the ore is scattered over the surface and in some places for a few inches below it. It is evidently

formed by segregation from a flow of older basalt that has decomposed to clay. What is seen on the beach represents accumulation for a vast period, and, if gathered up, there would be no succeeding accumulation. At various points along the east shore of Western Port similar deposits of poor quality limonite are met with, but in no case in large quantities (see assays No. 1 and 2). The quality varies greatly.

### Grantville.

About ½ mile east of Grantville in a gully the Tertiary grit is impregnated with limonite. This is exposed in the small creek-bed at a depth of about 20 feet below the general surface. Insufficient work has been done to determine the thickness of the lateral extent of the deposit. The limonite is associated with grains of quartz, and as the assay shows only 27·8 per cent. of iron, and it is a siliceous ore, it could not be profitably worked. This ore looks as though it had been formed right in Tertiary beds, but as there are basaltic outcrops close by the limonite may have originated through the decomposition of basalt which formerly capped this area.

About half a mile to the south of Grantville, a small hill is capped by fairly solid limonite. There is but a small extent of it, as its greatest diameter does not exceed a chain in length. Into it a hole has been sunk 3 feet, and there may be another foot or so in thickness; the quality is comparatively good (see assay No. 7). This limonite deposit is a superficial one, and has resulted from the decomposition of basalt that formerly covered the locality. In the ploughed paddock sloping northward from the outcrop small irregular pieces of limonite similar to the above have been ploughed up, and a shallow shaft that has been sunk just outside the fence on the east side of this paddock shows the deposit to be a superficial one. There is no lode here.

### Sandstone Island.

At Sandstone Island there occurrs a flaggy iron ore (carbonate of iron). A specimen assayed iron, 40·7 per cent.; gold, 1 dwt. 7 gr. per ton (see assay No. 3).

[14.5.10.]

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## ON THE OCCURRENCE OF FISH REMAINS AND A LINGULA IN THE GRAMPIANS, WESTERN VICTORIA.

*By Frederick Chapman, A.L.S., &c., Palæontologist to the National Museum, Melbourne.*

The age of the Grampian Sandstones has always been open to some doubt, owing to the absence of definite fossil remains. These rocks have been variously ascribed to the Mesozoic series (Lower Trias)[1], or to the Upper Palæozoic. Of the latter series they have been referred either to the Lower Carboniferous or to the Devonian[2]. The Lower Carboniferous rocks in the neighbourhood of Mansfield, Victoria, have already afforded a fairly rich fish-fauna, lately described by Dr. A. Smith Woodward[3]. The Upper

1. Krausé, F. Prog. Rep. Geol. Surv. Vict., Vol. I., 1874, p. 9.
2. Murray, R. A. F. Geology and Physical Geography of Victoria, 1887, p. 58.—"The Grampian Sandstones, in the western portion of the colony, constitute one of the two large Upper Palæozoic areas." Stirling, J. Prog. Rep. Geol. Surv. Vict., No. XI., 1899, p. 5.—"Either of Devonian or Carboniferous age." Dunn, E. J. In Year-book of Commonwealth of Australia, 1909, p. 86.—"Probably belongs to the Lower Devonian series." Gregory, J. W. Geography of Victoria, 2nd ed., 1912, p. 284.—"Lower Carboniferous.—The Grampian Sandstones, the Cathedral Sandstones and the sandstones of Mount Wellington."
3. Mem. Nat. Mus., Melbourne, No. 1, 1906.

Devonian series, represented by the Iguana Creek beds in Gippsland, have yielded only plant-remains, belonging to the ferns and cordaitales. It is to the Lower Carboniferous that the Grampian Sandstones undoubtedly belong, in view of the evidence now brought forward. At the same time it should be borne in mind that in Victoria we seem to have no true palæontological or stratigraphical break between the Devonian and the Carboniferous, as is the case in most other areas abroad where these two series are well developed.

Mr. W. H. Ferguson has done excellent service in discovering, for the first time, definite fossil remains in the Grampian Sandstones series. The genus, to which the ichthyodorulites or fish-spines are here referred, is essentially Lower Carboniferous in the northern hemisphere; and further than this, additional corroboration of the age of the sandstone is afforded by the occurrence in large numbers of a local variety of the well-known fossil, *Lingula squamiformis*, so typical of the Lower Carboniferous series in Great Britain.

The rocks in which the fossils described below are embedded consist of grey sandstone, and purplish micaceous mudstone. They are often rudely sun-cracked, the fissures being filled in with sandy-mud slightly differing in character from the general structure of the rock. In some layers the *Lingula* shells are crowded together in veritable sheets, having evidently drifted into small pools by tidal action. Here and there are worm-burrows filled with fine *débris*.

### Class PISCES.

#### Ichthyodorulites.

#### Genus **Physonemus**, McCoy.

"Spines laterally much compressed, strongly arched, often hook-shaped, base of insertion broad. Sides of exserted portion more or less ornamented with tuberculated longitudinal ridges; small denticles present upon the concave edge."[1]

The original description runs thus—"Gen. Char. Fin-spine of small or moderate size, much compressed, with a variable backward curvature; base of insertion large; posterior edge, with two rows of small denticles. Surface covered with very numerous cord-like longitudinal ridges, which swell at short regular intervals into smooth bubble-like tubercles."[2]

#### Physonemus micracanthus, sp. nov.

Plate V. Figs. 1, 2, 3.

*Specific Characters.*—Spines very small, more or less falcate, strongly compressed laterally. Sides showing from six to eight thin, longitudinal ridges, which are swollen at intervals into tubercles or bead-like prominences. The tubercles near the margin, especially at the base of the spine, appear to form blunt spinous processes. Interspaces between the ridges about twice the width of the latter. True bony structure (vasodentine) can be seen below the surface in decorticated specimens.

*Measurements.*

| | Length. mm. | Width of Base. mm. |
|---|---|---|
| Holotype .. .. | 7 | 1.5 |
| Paratype .. .. | 9.75 | 1.5 |

1. A. S. Woodward. Cat. Foss. Fishes, Brit. Mus. pt. II. 1891, p. 130.
2. F. McCoy. Brit. Pal. Foss., 1854, p. 638.

*Observations.*—From the foregoing measurements and the accompanying figures, it is seen that the spines show some variation in length, curvature and proportionate breadth ; but the general character leads one to infer that they all belong to one species. The ornament, also, differs to some extent, the longitudinal ridges in certain specimens being very pronounced owing to slight decortication, whilst in others the ridges are thicker. All the examples, however, show the distinctive character of the knotting of the ridges at short intervals.

The present genus was instituted by McCoy to include some small to moderate-sized spines found in the Lower Carboniferous limestone of Armagh, Ireland. The present species, *P. micracanthus*, shows certain related characters with *P. arcuatus*, McCoy[1]. The spines of *P. micracanthus* are curved, as in *P. arcuatus*, but are not nearly so large, nor are they so proportionately broad at the base.

In *Drepanacanthus* (=*Physonemus*), Newbery and Worthen[2] have noticed characters which they regard as evidence for the forward direction of the spines of this type ; but judging from the general arrangement of dermal processes on fishes, which are always conducive to their facile movement, this seems somewhat improbable.

Another genus of ichthyodorulites or fish-spines closely approaching the specimens now described, is *Asteroptychius*, McCoy (Agassiz MS.)[3]. The spines of this type, however, are furnished with marginal denticles and striated intercostal surface.

The ichthyodorulites are summarized by A. S. Woodward[4] in five classes, *Physonemus* being placed in the third group defined as " Paired spines, of which some may have been placed in front of fins, but of which many are broad, with insignificant base of insertion, and must have been arranged as independent dermal armour."

The exact morphological relationship of these spines from the Grampian Sandstones, like other species of the genus *Physonemus*, is doubtful and must await further evidence. It is a distinctly Lower Carboniferous type of fish, which by its association in England, Ireland and North America, with teeth of genera belonging to the *Cochliodontidæ*, may yet turn out to be more closely related to that family than we yet know. *Physonemus* has indeed already been placed in the Cochliodont family by Jaekel ; whilst Smith Woodward regards that family as nearly related to the *Cestraciontidæ* (example, Port Jackson sharks). In view of the importance of this occurrence in Victoria, and in order to secure further evidence of this interesting fauna, a renewed search should be made in this locality at the earliest opportunity.

*Locality.*—The holotype (No. 16076) comes from Mount Rosea, the paratype (No. 12833) from near Hall's Gap.

### Physonemus attenuatus, Davis.[5]

Plate. V. Fig. 4.

*Observations.*—Although the present specimen is much smaller than that from the Lower Carboniferous limestone of Armagh, described by J. W. Davis, yet in the broad form of the base and comparative straightness of the exsert portion, it approaches more nearly to this than to any other described species. Davis's specimen is 6 inches in length, whereas the Victorian example is not quite one and a quarter inches long. The Victorian specimen is distinguished from the previously described *P. micracanthus*, both in outward form and build, and also in internal structure.

1. Ann. Mag. Nat. Hist., ser. 2, vol. II., 1848, p. 117. Brit. Pal. Foss, 1855, p. 638, pl. III., I., Fig. 29 ; pl. III., K., Fig. 25. Davis, J. W., Trans. R. Dubl. Soc., ser. 2, vol. I., 1883, p. 367, pl. XLVII., Figs. 8, 8*a*.
2. Pal. Illinois, vol. II., 1866, p. 121.
3. Ann. Mag. Nat. Hist., ser. 2, vol. II., 1848, p. 118.
4. Cat. Foss. Fishes, Brit. Mus., pt. II., 1891, p. 93.
5. *Physonemus attenuatus*, Davis, 1883, Trans. R. Dublin Soc., ser. 2, vol. I., p. 369, pl. XLVII. Fig. 10.

*Description of Victorian Specimen.*—Spine having a broadly expanded base, the surface of which is deeply furrowed by about 20 longitudinal striæ. The riblets, under magnification, show a series of pits, probably the basis of decorticated tubercles. Length from base to extremity, 30 mm. Width at base, 9.5 mm.

## Genus **Lingula,** Bruguière.

### Lingula squamiformis, Phillips, var. borungensis, nov.

Plate. V. Fig. 5.

*Description.*—Shell, small elongate ovate, compressed at sides; with a broad anterior extremity, in some instances squarely ended as in *L. squamiformis* typica, in others, bluntly rounded. Surface of valves moderately strongly convex, with numerous concentric lines of growth. Shell much smaller than in *L. squamiformis,* Phillips,[1] which it otherwise closely resembles, excepting in an occasional departure from the square anterior border. Length of specimen figured, 3.5 mm. Breadth, 2.25 mm.

*Observations.*—The present specimens are very numerous in the red, clayey and sandy beds containing fish-spines, from Hall's Gap, Grampians. There is no doubt of their close relationship to Phillips's species, but their minute size (1:10), and tendency to vary in outline from that form, preclude a specific identification with that fossil.

Another species of *Lingula* has already been recorded from beds of similar age in New South Wales, near Canowindra, by Mr. Etheridge,[2] which that author has described under the name of *L. gregaria.* On comparing typical specimens of this species in the National Museum, it was seen, however, that the two forms are entirely distinct; *L. gregaria* has a longer and more ovate shell, and, as Mr. Etheridge remarks, it belongs to the type of *L. mytiloides,* Sowerby. It is interesting to note, in connexion with the occurrence of the Lower Carboniferous *Lingulæ* in this State and in New South Wales, the close resemblance of the Australian examples with the two well-known British species, *L. mytiloides,* Sow., and *L. squamiformis,* Phillips, both of Carboniferous age.

The following table shows the distribution of the specimens examined. The registered numbers are 12825-38, 16016, 16030, 16036, 16076 and 16077 :—

| Fossil. | Mt. Rosea. | Near Hall's Gap. |
|---|---|---|
| Physonemus micracanthus, sp. nov. .. .. .. | 1 specimen | 3 specimens |
| Physonemus (?) attenuatus, Davis .. .. .. | — | 1 specimen |
| Physonemus sp. .. .. .. .. .. | 2 specimens | 3 specimens |
| Lingula squamiformis, Phillips, var. borungensis, nov. | — | 5 specimens |

## Explanation to Plate V.

Fig. 1.—*Physonemus micracanthus,* sp. nov. Spine, enlarged 6 diameters. No. 16076 (holotype). Mount Rosea, Grampians. Lower Carboniferous.

Fig. 2.—*P. micracanthus,* sp. nov. Middle portion of above spine, more highly magnified (X 26). Lower Carboniferous.

Fig. 3.—*P. micracanthus,* sp. nov. Spine, enlarged 6 diameters. No 12833 (paratype). Hall's Gap, Grampians. Lower Carboniferous.

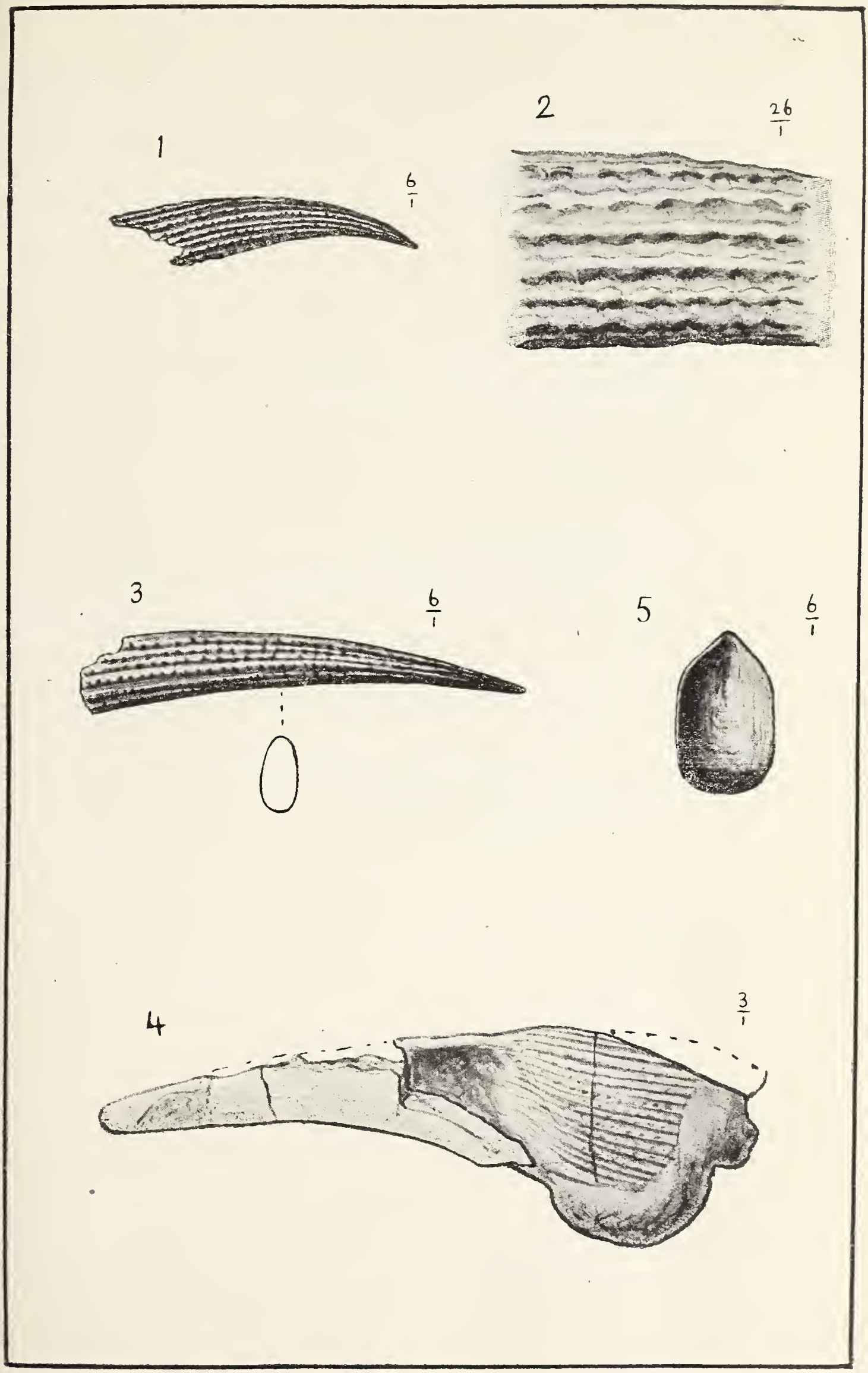
Fig. 4.—*Physonemus attenuatus,* Davis. Spine showing both basal and exsert portions; partly decorticated. Enlarged three times. No. 12828 (plesiotype). Hall's Gap, Grampians. Lower Carboniferous.

Fig. 5.—*Lingula squamiformis,* Phillips, var. *borungensis,* nov. Enlarged 6 diameters. No. 12835 (holotype of var.). Hall's Gap, Grampians. Lower Carboniferous.



1. Phillips, J., Geol. of Yorkshire, vol. II., 1836, pl. IX., Fig. 14. Davidson. T., Carboniferous Brachiopoda (Pal. Soc. Mon.), part V., 1861, p. 205, pl. XLIX., Figs. 1-10.
2. Rec. Aust. Mus., vol. IV., No. 3, 1901, pp. 119, 120, Fig. 14.

PLATE V.




F.C. ad nat. del.

LOWER CARBONIFEROUS FOSSILS. THE GRAMPIANS, WESTERN VICTORIA.

BRITISH MUSEUM
G D
NATURAL HISTORY

# REPORT ON CAMBRIAN FOSSILS FROM KNOWSLEY EAST, NEAR HEATHCOTE.

*By Frederick Chapman, A.L.S., &c., Palæontologist to the National Museum, Melbourne.*

7781. Fragment of a brachiopod, indet.
7782. Cranidia of *Dinesus ida*, Eth. fil. and pygidium of *Notasaphus fergusoni*, Gregory.
7783. *Clitambonites flabelloides*, Chapm. sp. (figd.).
7784. Trilobite fragments, indet.
7785. *Lingulella australis*, Chapm. (figd.).
7786. *Hebertella raristriata*, Chapm. sp. (figd.).
7787. Trilobite fragments, indet.
7788. Brachiopod fragments, indet.
7789. *Notasaphus fergusoni* (pygidium).
7790. Cranidium of *Dinesus ida* and pygidium of *Notasaphus fergusoni*.
7791. *Notasaphus* pygidium with numerous spines (figd.).
7792. Genal spine and free cheek of *Saratogia* cf. *hamulus*, Owen (figd.).
7793. Trilobite glabella, indet.
7794. Pleuræ of *Notasaphus fergusoni*.
7795. cf. *Saukia* sp., genal spine (figd.).
7796. Cranidium of *Dinesus ida*.
7797. Trilobite fragments, *Dinesus*, &c.
7798. Inferior portion of cephalon of *Notasaphus*.
7799. *Hebertella raristriata*, Chapm.
7800. Pygidium of ? *Dinesus ida* (figd.).
7801. ?Glabella of *Dinesus*.
7802. *Dinesus ;* and cf. *Saukia* sp., cranidium (figd.).
7803. *Dinesus* cranidium and other, indet, remains.
7804. Fragment of ? trilobite or ? cephalopod.
7805. Portions of cranidia of *Notasaphus* and *Dinesus ida*.
7806. Free cheek of ? *Notasaphus* (imperfect).
7807. Glabella of *Dinesus ida*.
7808. Trilobite fragments (tuberculate), indet.
7809. Trilobite fragments indet. and ? worm burrow.
7810. *Notasaphus fergusoni ;* pygidium with few spines and narrow axis (figd.).
7811. Indet. fragment.
7812. *Acrothele subquadrata*, Chapm. (figd.).
7813. Free cheek of trilobite, indet.
7814. Pygidium of *Notasaphus*, slightly distorted.
7815. *Notasaphus fergusoni* (pygidium) and *Dinesus ida* (cephalon).
7816. Trilobite fragments, indet.
7817. Fragments, indet.
7818. *Dinesus ida*, cephalon.
7819. Trilobite fragments, indet.
7820. Trilobite fragments, indet.
7823. Trilobite fragments, indet.
7821. *Notasaphus fergusoni* (pygidium).
7822. *Notasaphus fergusoni* (typical).
7824. Brachiopod fragment, indet.
7825, 7826, 7830. Pygidia of *N. fergusoni*.
7827. *Dinesus ida* (cephalon).
7828. Glabella of trilobite, indet.

7829. Portion of fixed cheek of trilobite, indet.
7831–5. *Notasaphus fergusoni ;* pygidia, good specimens.
7836. *Leptobolus truncata*, Chapm. (figd.).
7837. *Notasaphus fergusoni ;* good pygidium.
7838. *Billingsella fergusoni*, Chapm. (figd.).
7839. *Notasaphus ;* fragments.
7840. *Dinesus ida ;* cephalon.
7841. Fragments, indet.
7842. *Lingulella australis*, Chapm.
7843–4. Trilobite fragments, indet.
7845. *Dinesus ida*, glabella.
7846–7. *Notasaphus fergusoni ;* pygidia.
7848. Cephalon of trilobite, crushed, ? *Notasaphus*.
7849. *Dinesus ida*. A smooth ? decorticated cranidium showing neck ring and basal lobes (figd.).
7850. Cephalon of *D. ida*.
7851. *Notasaphus* and *Dinesus ;* fragments.
7852. *N. fergusoni*, pygidium.
7853. *Lingulella australis*, Chapm.
7854–8. *Dinesus ida*.
7859. *D. ida ;* good cephalon (figd.).
7860, 7862, 7865. *Notasaphus fergusoni ;* pygidia.
7861, 7864, 7866–8. Trilobite fragments.
7863. *Dinesus ida*.
7869–70. *Notasaphus*, pygidium.
7871–2. *Notasaphus ;* cephalon.
7873. Trilobite fragments, indet.
7874. Free cheek of trilobite, indet.
7875. *Notasaphus ;* fragments.
7876. *Dinesus ida ;* cephalon.
7877. Brachiopod fragment, indet. ; and *N. fergusoni*, pygidium.
7878. Indet.
7879. *Notasaphus ;* pygidium.
7880. Anterior margin of trilobite cranidium, indet.
7881. *Notasaphus ;* pygidium.
7882. *Notasaphus ;* frontal margin.
7883. *Dinesus ida ;* glabella.
7884, 7887, 7888, 7891. Trilobite fragments, indet.
7885. Brachiopod fragment, ?*Eoörthis*.
7886. Free cheek of cf. *Saratogia rugulata*, Chapm. (figd.).
7890. *Dinesus*, glabella ; *Notasaphus*, pygidium.
7892. ?*Dinesus*, cephalon.
7893. *Plectambonites flabelloides*, Chapm. sp. (figd.).
7894–5. *Notasaphus ;* pygidium.
7896. *N. fergusoni ;* crushed pygidium.
7897. *Dinesus ida ;* cephalon.
7898. *Notasaphus ;* pygidium.
7899. Fragments, indet.
7900. *Dinesus ;* cephalon.
7901–2. *Notasaphus ;* fragments.
7903. Trilobite fragments, indet.
7904. ?Annelid remains, indet.
7905. *Dinesus ida ;* papillate glabella.
7906–7. *D. ida ;* cranidia.

7908. Free cheek of trilobite, indet.
7909. *Clitambonites flabelloides*, Chapm. sp. (figd.).
7910–11. Cast and mould of pedicle valve of *Eoörthis flexilis*, Chapm. (figd.), Cotypes.
7912–3. Indet. remains.
7914. Trilobite fragments, indet.
7915–6. *Dinesus ida ;* cephalon.
7917–8. ?Brachiopod, indet.
7919, 7922, 7925. Trilobite fragments, indet.
7920. *Lingulella* sp.
7921. *Huenella divaricata*, Chapm. sp.
7923. Plicate orthid, indet.
7924. *Huenella divaricata*, Chapm. sp. (figd.).
7926. *Notasaphus fergusoni ;* nearly complete cephalon.
7927. Cephalon of trilobite ; crushed.
7928. *N. fergusoni ;* pygidium.
7929. *Acrothele brevis*, Chapm. (figd.).
7930, 7935, 7937, 7942. Trilobite fragments, indet.
7931. Pentameroid brachiopod, indet. and cranidium of *Dinesus ida* (figd.).
7932. *N. fergusoni ;* pygidium.
7933. *Clitambonites flabelloides*, Chapm. sp.
7934. *Dinesus ;* part of cranidium.
7936. ?
7938. Genal spine of trilobite, cf. *Saukia* sp. (counterpart of 7795).
7939. Genal spine of trilobite.
7940. ?*Grammysia heathcotiensis*, Chapm. (figd.).
7941. ?*Lingulella.*
7943–4. *Dinesus ida ;* cephalon.
7945. *Dinesus.*

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## THE HEATHCOTE FAUNA.

*By Frederick Chapman, A.L.S., &c., Palæontologist to the National Museum, Melbourne.*

(Plates VI. and VII.)

### Source of the Present Collection.

The following notes are the result of an examination of a series of fossils recently collected by Mr. W. H. Ferguson, of the Victorian Mines Department, together with a re-examination of the former series described by Prof. J. W. Gregory and myself.[1] and a supplementary collection received from Prof. E. W. Skeats, D.Sc., F.G.S. The fossils were obtained from a band outcropping in paddocks at Knowsley East, and were first discovered by Mr. Ferguson, about 1894. Some of the early specimens were also collected by Mr. Lidgey.

[1] Gregory, J. W. Proc. R. Soc. Vict., vol. XV., pt. II. (N.S.), 1903, pp. 154–156, pl. XXVI.
Chapman, F. Rec. Geol. Surv. Vict., vol. I., pt. 3, 1904, pp. 222–6, pl. XXI.

## Previous Work.

Mr. R. Etheridge, jun., examined specimens of the trilobite remains in 1894, and founded thereon the genus *Dinesus*, his paper[1] being published in 1896. In this paper Mr. Etheridge quotes a letter sent to him by Dr. C. D. Walcott, the authority on America Cambrian faunas, who expressed the opinion that the Heathcote trilobites "undoubtedly belong to the Middle Cambrian fauna, as they are not of the type found in the Upper or Lower Cambrian."[2]

Mr. Etheridge afterwards recorded the genus *Protospongia* from Heathcote (Dinesus ida beds)[3] and compared it with *P. fenestrata*, Salter (Middle Cambrian of Wales), *P. reticulata*, T. S. Hall (Lower Ordovician, Bendigo), and similar spicules from the Cambrian of North America figured by Dr. C. D. Walcott. It is important to note in this connexion Prof. Skeats' discovery of *Protospongia* in the normal Lower Ordovician rocks at Heathcote,[4] the genus having been previously described from similar beds at Lancefield and Bendigo.

Some years later Prof. Gregory devoted a section of his paper on "The Heathcotian—A Pre-Ordovician Series—and Its Distribution in Victoria"[5] to the description of the fossils of the *Dinesus ida* beds. The pygidium referred to *Dinesus* by Mr. Etheridge is therein made the type of a new genus, *Notasaphus*, together with some cranidial remains differing from *Dinesus*.[6]

The present writer, in 1904, published some results of an examination of casts and moulds of brachiopods found in the Mt. Ida beds by Mr. Ferguson, and came to a similar conclusion with Prof. Gregory that the beds were of Ordovician age.[7]

A few years ago Mr. W. H. Ferguson paid another visit to Knowsley East, and made a far larger collection of fossils than on the former occasion. Realizing the importance of arriving at a more definite conclusion as to the geological horizon of this fauna, and its bearing on other related faunas in Victoria, Prof. Skeats and Mr. E. J. Dunn (late Director of the Victorian Geological Survey) suggested that the writer should undertake the re-examination of the fossils, the results of which are now submitted. It is only fair to add that this present work has been made much easier through the copius descripitions of Cambrian faunas in China and North America by Dr. C. D. Walcott, of the United States National Museum. Thus one distinctive genus of brachiopod, *Huenella*, formerly thought to belong to the Orthidæ both by Mr. Etheridge and myself, is shown by Dr. C. D. Walcott to be a member of the Pentameracea. It is represented by at least one species in the Cambrian of South Australia and by another in the present fauna. In regard to the previous determination of brachiopods from Knowsley East by the writer, comparisons had to be made with similar forms found elsewhere, hence the references in many instances to the better known Ordovician and Silurian genera, to which, judging from the sparse material available, they then seemed to belong. It is satisfactory to find so strong a light thrown on the question of the age and relationships of the Heathcotian fauna, not only by the distinctive genus *Huenella* above mentioned, but by others known to occur in the Cambrian faunas elsewhere in the southern hemisphere.

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[1] "Evidence of the Existence of a Cambrian Fauna in Victoria." Proc. R. Soc. Vict., vol. VIII. (N.S.), 1896, pp. 52–64.
[2] *Loc. cit.*, p. 55.
[3] Geol. Surv. Vict., Monthly Prog. Rep., No. 11, 1900, p. 23.
[4] Proc. R. Soc. Vict., vol. XXI. (N.S.), pt. I., 1908, p. 341. Cf. *idem*. Rep. Aust. Assoc. Adv. Sci., Brisbane, 1909, p. 177.
[5] Proc. R. Soc. Vict., pt. II. (N.S.), 1903, pp. 148–175, pls. XXIII.–XXVI.
[6] *Loc. cit.*, p. 155, pl. XXVI.
[7] "On Some Brachiopods and a Bivalve from Heathcote." Rec. Geol. Surv. Vict., vol. I.. pt. 3, 1904, pp. 222–6, pl. XXI.

## Age Affinities of the Fauna.

The trilobites and brachiopods possibly afford the best evidence as to the relative age of the Knowsley beds at Heathcote. Amongst the former group *Dinesus* is perhaps the commonest genus, but its relationship to other known genera is not very clear. It has been compared with *Lloydia*, a form apparently more closely allied to *Solenopleura* than to *Bathyurus*, the former genus ranging through Cambrian and Ordovician. In this series *Notasaphus* occurs fairly abundantly as regards the pygidial portion, whilst cranidia are not infrequent, and one exceptionally good specimen is now figured. The genus is almost essentially of an Upper Cambrian type, and is closely related to *Dorypyge*, from which it differs chiefly in the expanding glabella and the less strongly marked side furrows. The pygidia in both genera are almost identical. In view of this close relationship it is interesting to note that *Dorypyge* is regarded by Walcott, who has described at length the relationships of the Chinese trilobite faunas, to typify the Middle Cambrian series.[1] *Saratogia* appears to be represented in the Heathcote fauna by an Upper Cambrian form, which elsewhere is found in the Potsdam formation of North America. The cranidia referred provisionally to *Saukia* seem also related to an Upper Cambrian species. The occurrence here of *Agnostus australiensis* is valuable evidence of age, having regard to its previous discovery in the Upper Cambrian limestone of the Dolodrook River, N.E. Gippsland.

Of the ten genera of brachiopods recorded from this fauna five are typically Cambrian, viz., *Lingulella*, *Acrothele*, *Billingsella*, *Eoörthis*, and *Huenella*. Three are Cambrian genera, ranging into the Ordovician, viz., *Obolus*, *Acrothele*, and *Billingsella* (dying out in L. Ordovician). Those purely of Ordovician aspect are *Leptobolus*, *Hebertella*, *Eostrophomena* (basal Ordovician), and *Clitambonites*. Six genera extend down to Middle Cambrian and older, viz., *Obolus*, *Lingulella* (throughout), *Acrothele* (throughout), *Billingsella* (throughout), *Eoörthis* (Middle Cambrian to Lower Ordovician), and *Huenella* (Middle and Upper Cambrian). Thus it will be seen that the balance of the forms represented point to a Cambrian facies.

Of the other genera, *Grammysia* does not seem to have been recorded from beds older than the Trenton Series (Lower Ordovician), so that assuming the present form to belong to this genus its range is now extended.

The branchiopod, *Lepeditta*, occurs in the Cambrian of North America.

Regarding *Protospongia*, this seems to be restricted to the Cambrian elsewhere, the related genus *Phormosella* only being recorded from younger (Silurian) beds. In South Australia *Protospongia* is a Lower Cambrian fossil.

The thallophyte, *Sphenothallus*, was previously known only from the Upper Ordovician (Hudson River Group).

Summing up this evidence, the strongest factors in the fauna are those of the trilobites, which appear to show close Upper Cambrian affinities, and the brachiopods, as *Lingulella*, *Acrothele*, and *Billingsella*, of Cambrian age, as well as the branchiopod, *Lepeditta*. Less common forms are those of Ordovician aspect, as *Eostrophomena*, *Clitambonites*, *Grammysia*, and *Sphenothallus*. So far as the present study goes it points to an Upper Cambrian horizon, the fauna having secondary affinities both with the Middle Cambrian and Lower, and even Upper Ordovician. It is therefore an extremely interesting case of a passage fauna with an admixture of forms that are of wide range in other localities.

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[1] Smithsonian Misc. Colls., vol. LXIV., No. 1, 1914, pp. 64–65 *et seq.*

## GENERA AND SPECIES IN THE UPPER CAMBRIAN OF KNOWSLEY EAST, HEATHCOTE.

PLANTÆ—

Sphenothallus filicoides, sp. nov.

ANIMALIA—

BRACHIOPODA.

Obolus obovata, Chapm. sp.
Lingulella australis, sp. nov.
Leptobolus truncata, sp. nov.
Acrothele subquadrata, sp. nov.
Acrothele brevis, sp. nov.
Billingsella tenera, Chapm. sp.
Billingsella fergusoni, sp. nov.
Eoörthis flexilis, sp. nov.
Hebertella raristriata, Chapm.
Eostrophomena skeatsi, sp. nov.
Huenella divaricata, Chapm. sp.
Clitambonites flabelloides, Chapm. sp

PELECYPODA—

Grammysia heathcotiensis, sp. nov.

TRILOBITA—

Agnostus australiensis, Chapm.
Dinesus ida, Eth. fil.
Saratogia cf. hamulus, Owen sp.
?Saratogia rugulata, sp. nov.
cf. Saukia, sp.
Notasaphus fergusoni, Gregory.

BRANCHIOPODA—

Lepeditta knowsleyensis, Chapm. sp.

## DESCRIPTION OF SPECIMENS.

### PLANTÆ—Series THALLOPHYTA.

### GENUS **Sphenothallus**, J. Hall.

SPHENOTHALLUS FILICOIDES sp. nov. Plate VI. fig. 1.

*Description.*—Frond thin, with axis slightly differentiated from branches. Branches or leaflets elongated, sub-ovate to wedge-shaped, thickened in median area by a rounded midrib. Length of specimen about 12 mm.; basal leaflets from 4 to 7 mm. in length.

*Relationships.*—This form appears to be nearest to *Sphenothallus angustifolius*, J. Hall,[1] which was found near Schoharie, New York State, in the Hudson River Group (Bala Series). It is distinguished from *Bythotrephis* in having a more definite stipe to which are attached the sphenoidal or ovate leaflets. Another striking feature of the genus is the rounded midrib in each leaflet. The Heathcote species differs from the North American in the shorter and less definitely sphenoidal shape of the leaflets; otherwise there is a striking resemblance between them, which is certainly generic.

*Sphenothallus filicoides* was collected by Professor E. W. Skeats.

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[1] Pal., N. York, vol. I., 1848, p. 261, pl. LXVII., fig. 1.

ANIMALIA—Class BRACHIOPODA.

Fam. OBOLIDÆ.

GENUS **Obolus,** Eichwald.

OBOLUS OBOVATA, Chapman sp.

*Siphonotreta obovata,* Chapman, 1904, Rec. Geol. Surv. Vict., vol I., pt. 3, p. 222, pl. XXI., fig. 1.

*Siphonotreta discoidalis.*—Idem, ibid., p. 223, pl. XXI., figs. 2, 2*a*.

*Observations.*—The mould of the shell formerly described as *Siphonotreta discoidalis* shows a distinct impression of a pedicle channel which is apparently open. The shell was smooth but for the fine concentric markings. The mould (spec. 22) is now found to be the counterpart of spec. 3, and as the latter, named *obovata*, is the first figure on the plate, this name now stands for both fossils.

*Relationships.*—The above species reminds one of *Obolus parvus*, Walcott,[1] a Lower Cambrian fossil of the Canadian Rocky Mountains, from which it differs in its more regularly rounded form and deeper valve.

GENUS **Lingulella,** Salter.

LINGULELLA AUSTRALIS sp. nov. Plate VI., figs. 2, 2*a*.

*Description.*—Shell ovate, longer than wide, depressed. Beak acuminate. Anterior margin broadly rounded. Surface with fine and coarse concentric lines, the latter resembling folds in the shell.

*Dimensions.*—Length, 3·66 mm. ; greatest width, 2·66 mm.

*Relationships.*—A nearly allied form to the above is *Lingulella lepis.* Salter sp.[2] from the Lingula Flags and Tremadoc Beds (Upper Cambrian) of Wales.[3] The British specimens differ in having uniformly fine concentric striæ and no folds on the shell.

GENUS **Leptobolus,** Hall.

LEPTOBOLUS TRUNCATA, sp. nov. Plate VI., figs. 3, 3*a*.

*Description.*—Pedicle valve subtrigonal in outline ; lateral and anterior margins widely curved. Apex, sub-acute. Pedicle channel extensive ; diverging septa and muscular scars well pronounced. Surface marked by fine concentric growth-lines.

*Dimensions.*—Length, 3·33 mm. ; width, 3·5 mm.

*Relationships.*—The small size and divergent septa point to the affinities of this oboloid shell with *Leptobolus.* The nearest allied form is perhaps *Leptobolus occidentalis,* J. Hall,[4] a fossil of the Utica Group (Ordovician) of New York State.

Fam. ACROTRETIDÆ.

GENUS **Acrothele,** Linarsson.

ACROTHELE SUBQUADRATA, sp. nov. Plate VI., figs. 4, 4*a*.

*Description.*—Ventral valve subquadrate in outline. Apex slightly posterior to the centre of the valve. Lateral margins curving towards the false area, which is triangular, slightly concave, and bordered by lines radiating from the apex to the posterior margin. Surface from the apex to the anterior margin well arched. Shell-surface marked with distinct concentric lines of growth.

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[1] Smithsonian Misc. Colls., vol. LIII., No. 1810, 1908, p. 61, pl. VIII., figs. 10, 10*a*.

[2] Mem. Geol. Surv. Gt. Brit., vol. III., 1866, p. 334, fig. 11. Davidson, Mon. Brit. Sil. Brach. (Pal. Soc.), 1866, p. 54, pl. III., figs. 54–58. *Id.*, Geol. Mag., Dec. I., vol. V., 1868, p. 307, pl. XV., figs. 10–12,

[3] The Tremadoc Beds are generally regarded either as Cambrian or as a passage series between the Cambrian and the Ordovician. Kayser and Lake, in the Text-book of Comparative Geology (p. 51), place it in the Ordovician.

[4] Twenty-fourth Report N. York State Mus. Nat. Hist., p. 227, pl. VII., fig. 18.

*Dimensions.*—Length, 3·33 mm.; width, 3·33 mm.; apical height, 1 mm.

*Relationships.*—*Acrothele woodworthi*, Walcott,[1] a Lower Cambrian fossil from Massachusetts, is not far removed from the above species, but is not so distinctly quadrate nor so clearly defined as to its false area. The Middle Cambrian species, *A. matthewi* var. *eryx*, Walcott,[2] is remarkably near, but the apex is closer to the posterior margin. It is also a much larger form.

ACROTHELE BREVIS, sp. nov. Plate VI., figs. 5, 5*a*.

*Description.*—Ventral valve semicircular; width greater than length. Posterior margin nearly straight, anterior well rounded. Apex situated close to the posterior margin, hence the false area is broad and short. Anterior slope of shell distinctly convex, the posterior slope concave. Shell surface marked with concentric lines of growth.

*Dimensions.*—Length, 2·16 mm.; width, 3·16 mm.; height at apex, ·916 mm.

*Relationships.*—In the widely expanded shell, narrow false area and sub-central position of the apex of the ventral valve the above species bears some resemblance to *Acrothele levisensis*, Walcott,[3] from the Lower Ordovician shales of Point Lévis, Quebec, Canada.

## Fam. BILLINGSELLIDÆ.

## GENUS **Billingsella**, Hall and Clarke.

BILLINGSELLA TENERA, Chapman sp. Plate VI., fig. 6.

*Orthis tenera*, Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 223, pl. XXI., figs. 8, 8*a*.

*Observations.*—The original drawings given in 1904 do not adequately express the median folding of this shell, and I have therefore redrawn it. The median fold is marked with a faint sulcus. In some respects the shell resembles *Nisusia*, but the internal structure shown is not sufficient to make a close comparison possible. The pedicle foramen is distinctly seen, as well as the depressions in the cast which mark the bases of the cruræ, whilst a cardinal process seems to be shown in the specimen.

*Relationships.*—In some respects the above species resembles *B. tonkiniana*, Mansuy[4], but the plication of the Heathcote species is not so pronounced. The dimensions are about the same in both forms. Mansuy regards his species as Middle Cambrian.

BILLINGSELLA FERGUSONI, sp. nov. Plate VI., figs. 7–9.

*Rhynchonella* (?*Camarotœchia*) sp., Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 224, pl. XXI., fig. 10.

*Description.*—Shell broadly ovate, cardinal line rather short, with cardinal extremities sloping to meet the widely rounded anterior margin. The postero-lateral areas bevelled, the median area depressed giving rise to two elevated areas diverging from the cardinal line to the extemities of the anterior margin. Shell-surface folded into eight prominent well-rounded riblets. The type specimen (7838) probably represents a dorsal valve, the paratype (refigured from Rec. Geol. Surv. Vict. 1904) a ventral valve. The latter has been further cleared of matrix since it was first figured, and this has confirmed its identity with the second (type) specimen. There is also a cast of an orthid (No. 7799) which may reasonably be assumed to belong to the above species.

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[1] Cambrian Brachiopoda. Smithsonian Misc. Colls., vol. LIII., No. 1810, 1908, p 88, pl IX., fig. 11.
[2] Cambrian Faunas of China. Proc. U.S. Nat. Mus., vol. XXIX., 1906, p. 11.
[3] Camb. Brach. Sm. Misc. Colls., vol. LIII., No. 1810, 1908, p. 85, pl. VIII., fig. 13.
[4] Mem. Serv. Geol. de l'Indochine, vol. IV., fasc. II., 1915, p. 7, pl. I., f. 2 *a–q*.

*Dimensions.*—Type specimen : length, 5·16 mm. ; width, 8·3 mm.

*Relationships.*—The coarse plications in this shell resemble to some extent those of *B. major*, Walcott,[1] from the Upper Cambrian of Wisconsin. Our species differs not only in the fewer folds but in the bevelled shoulders and deeply depressed median area.

## Genus **Eoörthis**, Walcott.

### Eoörthis flexilis, sp. nov. Plate VI., figs. 10–11.

*Description.*—Pedicle valve depressed convex, incurved at the margins, subcircular in outline, with straight cardinal line and acutely produced extremities. Anterior margin somewhat truncate, sides obliquely rounded. Surface relieved by about 17 radiating folds, inclined to be flexuose and with a few secondary ribs interspaced between the main folds. No. 7910 is a natural cast of the pedicle valve, and 7911 is copied from a wax squeeze of the mould of the same valve.

*Dimensions.*—Length, 3·33 mm. ; width, 7·16 mm.

*Relationships.*—Probably the nearest allied form is *Eoörthis merope* Billings sp.[2], from the lowest beds of the Trenton Limestone. It differs from our species in the greater number of riblets, but agrees perfectly in outline.

*E. flexilis* is also closely related to *Eoörthis carausii*, Salter sp.[3], of the Lower Arenig of Wales, but the width of the latter shell is much less in proportion to height.

### Eoörthis concinna, Chapman sp.

*Chonetes concinna*, Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 223, pl. XXI. fig. 3.

*Observations.*—This fossil was formerly referred to *Chonetes*, partly on account of the negative cavity of the cardinal line being bridged across by mineral replacements which may originally have been based on a striated condition of the shell in that area. A similar denticulate structure is seen in *Eoörthis kayseri*, Walcott sp.[4]. The form of the value is subquadrate, with a straight hinge—line and strong median sulcus on the ventral surface (not dorsal as stated in original description). The shell was probably of thin texture and finely and numerously striated.

*E. concinna* generally resembles certain species of the genus found in Middle and Upper Cambrian beds in North America and China, though none appears to be closely related excepting perhaps *E. linnarssoni*, Kayser sp.[5], from the Upper Cambrian of Shan-tung, which differs in the coarser costation and more evenly rounded outline of the valve. The above species also appears to be related to *E. flexilis* of the Heathcote series, but the valves are longer and the ornament finer.

### Eoörthis vespertilioides, Chapman sp.

*Orthis* (*Hebertella*) *vespertilioides*, Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 224, pl. XXI., fig. 6.

*Observations.*—A ventral valve, having a strong median sinus and inflated lateral areas. It is of the general type of *Eoörthis kichouensis*, Walcott sp.[6], of the middle Cambrian of Shan-si, China ; but the Heathcotian species is more laterally elongate and with acute cardinal angles.

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[1] Smithsonian Misc. Colls., vol. LIII., No. 1810, 1908, p. 101, pl. X., figs. 1, 1*a*.
[2] *Orthis merope*, Billings. Geol. Surv. Canada, Pal. Fossils, vol. I., 1865, p. 139, fig. 116 *a–c*.
[3] *Orthis carausii*, Salter, Davidson. Geol. Mag., 1868, p. 315, pl. XVI., fig. 23.
[4] Research in China, vol. III., 1913, pl IV., fig. 8*b*.
[5] *Orthis linnarssoni*, Kayser, in Richthofen's "China," vol. IV., 1883, p. 34, pl. III., fig. 1. *Eoörthis linnarssoni*, Kayser sp, Walcott, Research in China, vol. III., 1913, p. 83, pl. IV., figs. 11, 11*a*.
[6] Research in China, vol. III., 1913, p, 82, pl IV., fig. 10.

EOÖRTHIS PLATYSTROPHOIDES, Chapman sp.

*Orthis ? leviensis*, Etheridge fil., Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 223, pl. XXI., fig. 4. *Plectorthis platystrophoides*, Chapman, 1911, Proc. R. Soc. Vict., vol. XXIII. (N.S.), pt. II., p. 311, pt. LIX., figs. 14, 15 ; pl. LX., fig. 24.

*Observations.*—A further examination of this specimen by means of wax squeezes shows that Etheridge's species differs in having a distinctly flexed type of valve, whilst ours is evenly and strongly convex. It agrees in all the preserved characters with the form *Eoörthis* (*Plectorthis*) *platystrophoides* described from the Upper Cambrian of the Dolodrook River, N.E. Gippsland. The riblets are strong, about sixteen in number, and with occasional finer ones in the interspaces.

The occurrence of the above species in the Heathcote series adds another link to its connexion with the Mount Wellington Upper Cambrian, *Agnostus australiensis* having been previously recorded from the Heathcote fauna.

## Fam. ORTHIDÆ.

## GENUS **Hebertella,** Hall and Clarke.

HEBERTELLA RARISTRIATA, Chapman. Plate VI., fig. 12.

*Orthis* (*Hebertella*) *raristriata*, Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 224, pl. XXI., figs. 7, 7*a*.

In this species the area is high, reminding one of *Clitambonites*, but the internal structure resembles that of *Hebertella*. The figure given in 1904 requires some correction, the cardinal extremities being too produced ; they are in reality more rounded, giving a subquadrate outline to the shell.

No. 7786 is a cast of a brachial valve of what appears to be the same species, and this shows the *Orthis*-like character fairly well.

## Fam. STROPHOMENIDÆ.

## GENUS **Eostrophomena,** Walcott.

EOSTROPHOMENA SKEATSI, sp. nov. Plate VI., fig. 13.

*Description.*—The following is founded on a cast and mould of a ventral valve :—

Shell of moderate size ; nearly semicircular in outline ; cardinal line straight. Ventral valve moderately convex, slightly depressed near the cardinal extremities, and at the middle of the anterior margin. Cardinal process prominent and subacute. Surface of valve ornamented with about 28 main riblets, with finer intermediate ones, and these are crossed by undulating lines of growth of a tegulate character.

*Dimensions.*—Length, 9 mm. ; width, 14 mm. ; greatest height of ventral valve, 2 mm.

This fine example (cast and mould) is named after its discoverer, Prof. E. W. Skeats, D.Sc.

*Relationships.*—In general shape and proportion of riblets the above species resembles " *Leptæna* " *plicifera* of James Hall[1], which occurs at Chazy, Clinton Co., New York, and is of Arenig age. It differs in the absence of the concentric tegulate ornament.

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[1] Pal., N. York, vol. I. 1848, p. 19, pl. IV.(bis), fig. 1*a*, *b*.

## Fam. Syntrophiidæ.

### Genus **Huenella,** Walcott.

Huenella divaricata, Chapman sp. Plate VI., fig. 14.

*Orthis* (*Bilobites*) *divaricata,* Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 224, pl. XXI., fig. 9.

*Observations.*—This shell appears to be a numerously costate form of the Cambrian genus, *Huenella.* The number of plicæ is doubled at half the distance to the anterior margin by the interposition of secondary riblets. The type specimen, figured in 1904, represents a ventral valve, whilst that now shown is a dorsal valve.

*Relationships.*—The above species shows some affinity to *Huenella lesleyi,* Walcott[2], from the Upper Cambrian of Utah, but it has a shorter cardinal line and more pronounced divaricate costation.

## Fam. Clitambonitidæ.

### Genus **Clitambonites,** Pander.

Clitambonites flabelloides, Chapman sp. Plate VI., figs. 15–17.

*Strophomena flabelloides,* Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 223, pl. XXI., fig. 5.

*Emended description.*—Shell quadrate, with a straight cardinal line and sloping, rounded, or subangulate margin. Cardinal area high. Spondylium large, often occupying half the length of the ventral valve. External surface deeply plicate, with a variable number of folds, sometimes eighteen, according to the development of secondary riblets between the major folds of the shell.

*Dimensions.*—Type specimen, length and width, 5·6 mm. Other examples: length, 4 mm.; width, 8·16 mm. (probably distorted); and length, 6·33 mm.; width, 6·66 mm.

*Observations.*—None of the hitherto described forms of *Clitambonites* show so strong a plication, and it may therefore be necessary to institute a new genus for these forerunners of the Lower Ordovician fossils.

## Class PELECYPODA.

## Fam. Grammysiidæ.

### Genus **Grammysia,** Verneuil.

(?)Grammysia heathcotiensis, sp. nov. Plate VI., fig. 18.

*Description.*—Shell elongate ovate; highest in the anterior third; length more than three times the height. Umbo not prominent, but convexly rounded. Specimen broken in front, but probably with a rounded border tapering posteriorly, with extremity acute. Umbonal sulcus distinct, as a shallow oblique fold, which sinuates the ventral margin of the shell. Ornament consisting of four or five undulating low ridges which ventrally appear to interdigitate.

*Dimensions.*—Length, circ., 16 mm.; height, 5 mm.

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[3] Smithsonian Misc. Colls., vol LIII., 1908, No. 1810, p. 110, pl. X., figs 12, 12*a*.

*Observations.*—Although the history of *Grammysia* is assumed to commence in the Llandovery, the above species seems to naturally fall into this genus. The folded shell-surface, with interdigitating rugæ, are characters not seen in *Modiolopsis* "sensu stricto," to which genus it might otherwise belong. A similar form of shell is "*Modiolopsis*" *parallela*, J. Hall[1], of the Trenton Limestone, New York State, but this differs chiefly in the truncated posterior and less pronounced rugæ. Although this fossil has the appearance of a true pelecypod, we bear in mind that some ceratiocarids described by Mansuy as *Sinocaris*[2] approach it in outline and ornament. The crustacean genus, however, is of Silurian age, and the superficial aspect is more depressed.

## Class TRILOBITA.

### Fam. Agnostidæ.

### Genus **Agnostus,** Brongniart.

#### Agnostus australiensis, Chapman.

*Agnostus australiensis*, Chapman, 1911, Proc. R. Soc. Vict., vol. XXIII. (N.S.), pt. II., p. 314, pl. LVIII., figs. 9, 11, 12.

*Description.*—A specimen from Heathcote in the University collection shows the pygidium and traces of thoracic segments. The pygidium is oval, with a rather broad middle lobe, but narrowing towards the back. The specimen is crushed and slightly distorted, owing to its occurrence in a compressed, red shaly rock. In an oblique light the outline of the middle lobe can be distinctly made out, and its correspondence with *Agnostus australiensis* verified.

*Observations.*—The occurrence of *A. australiensis* in the Heathcote fauna helps to support the view that the Dolodrook limestone area may be on practically the same horizon. The differences in the faunas from the two localities may be readily explained by the totally distinct lithological conditions of the beds in question; that of Heathcote indicating a muddy shore-line, subject to deposits of detrital or terrigenous material, whilst the Mount Wellington area shows a deeper water and less turbid condition of the sea at that period.

### Fam. ?Olenidæ.

### Genus **Dinesus,** R. Etheridge, jun.

#### Dinesus ida, Etheridge fil. Plate VII., figs. 19–22.

*Dinesus ida* (pars.), Etheridge, jun., 1896, Proc. R. Soc. Vict., vol. VIII. (N.S.), part I., p. 56, pl. I., figs. 1–4, 7. Gregory, 1902, ibid., vol. XV. (N.S.), pt. II., p. 154, pl. XXVI., figs. 8–10.

*Observations.*—In Etheridge's original description of *Dinesus ida* that author included the pygidium of another form, since named *Notasaphus* by Prof. Gregory. Thus the comparisons based on the Heathcote pygidia cannot hold good, but Mr. Etheridge makes some cogent remarks on the relationships of the cranidium of *Dinesus*, in which the affinity to Lloydia is pointed out, especially with regard to the feature of the circumscribed lobes at the base of the glabella (*loc. cit.*, pp. 59 and 62).[3] In his original description, Etheridge states that the glabella of *Dinesus* has no furrows, and this is generally the case; but on one example, better preserved than usual, there are two transverse furrows anteriorly concave at the sides and meeting in a central

[1] Pal., New York, vol. I., 1847, p. 158, pl. XXXV., fig. 5.
[2] Mem. Serv. Geol. de l'Indochine, vol. I., fasc. II., pt. II., 1912, pp. 36–37, pl. V., f. 10, 11.
[3] The genus *Lloydia* was suggested by Vogdes, who selected as genotype *Bathyurus bituberculatus* Billings (Geol. Surv., Canada, Palæozoic Fossils, vol. I., 1865, p. 410, fig. 391).

point directed forward as in those of *Paradoxides*. The circumscribed lobes, both anterior and posterior, so characteristic of this genus, are in this example very well marked, and seem to be sub-triangular. All the cranidia are superficially strongly granulate, and this constitutes another distinctive character separating this genus from other allies.

J. W. Gregory has figured (*loc. cit.*, pl. XXVI., fig. 8) a cranidium of *Dinesus* with two thoracic segments; these latter show a broad axis with narrow pleuræ, which features are not very characteristic of the *Bathyuridæ*. Very closely akin to the figure of the *Dinesus* cranidium with thoracic segments given by Gregory is that of *Ptychoparia orestes*, Hartt sp.,[1] from the St. John formation of New Brunswick, which Dr. Walcott has figured as Hartt's type of *Conocephalites halli*, now merged into the fore-named species. In this there are a similar ovate and deeply margined glabella and narrow pleuræ.

A pygidium is here figured which may possibly belong to *Dinesus*. It is too short for *Ptychoparia*, which in some points it otherwise resembles, and the axis and lateral divisions are in keeping with the character of the *Dinesus* thorax.

### Genus **Saratogia**, Walcott.

Saratogia cf. hamulus, Owen sp. Plate VII., fig. 23.

*Observations.*—The genal spine here figured bears a very close resemblance to the "fish hook spine" figured by Owen[2] under the name of *Lonchocephalus hamulus*; the only difference being in the less pronounced curve of the spine at the genal angle in the present form. *S. hamulus* is an Upper Cambrian species from the Franconia formation of Wisconsin, U.S.A.

? Saratogia rugulata, sp. nov. Plate VII., fig. 24.

*Description.*—The specimen here referred tentatively to the genus *Saratogia* is a free cheek resembling that of a ptychoparian, having a strongly wrinkled or furrowed surface and thickened border. The eye lobe is represented by a median crescentic margin. It probably belongs to a stout, heavy type of trilobite, judging from the thick rugose character of the specimen. The facial suture, with its deeply crescentic eye lobe, resembles that of *Saratogia calcifera*, Walcott sp.[3]. In depth from back to front of this free cheek is 7 mm., and its total width, 10 mm.

The genus *Saratogia* is described by Dr. C. D. Walcott as having cranidia and free cheeks not unlike those of *Crepicephalus iowensis*, Owen, and *Ptychoparia diademata*, except that the fixed cheeks are narrow in *Saratogia*. This genus is typically Upper Cambrian, but its range extends downwards into the Middle Cambrian.

### Fam. Dikellocephalidæ.

### Genus **Saukia**, Walcott.

Cf. Saukia sp.. Plate VII., figs. 25–26.

*Observations.*—The cranidium provisionally referred to this genus has glabella slightly expanding in front, the frontal lobe of which is tumid. The glabella is divided by two deep lateral furrows extending across the glabella, and there is a narrow occipital ring present which is somewhat crushed. The fixed cheeks are divided from the glabella by deep narrow furrows, and are apparently long elliptical, cut off transversely at the base,

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[1] Walcott. Bull. U.S. Geol. Surv., No. 10, 1884, p. 39, pl. V., fig. 3.

[2] Rep. Geol. Surv., Wisconsin, Iowa and Minnesota, Philadelphia, 1852, pl. Ia., fig. 8. See also Walcott, Smithsonian Misc. Colls., vol. LXIV., No. 3, 1916, p. 195.

[3] *Conocephalites calciferous*, Walcott. Thirty-second Ann. Rep., New York State Mus., 1879, pp. 129–130. *Saratogia calcifera*, Walcott sp. Smithsonian Misc. Colls., vol. LXIV., No. 3, 1916, p. 197, pl. XXXIV., figs. 6, 6 *a–e*.

and the surface decorticated. The frontal border is grooved behind, and margined by a salient limb. In some respects this cranidium resembles that of *Saukia pepinensis*, Owen sp.[1]

There is also, represented by fig. 26, a stout, falcate genal spine, with part of the free cheek, of a form allied to *Dikellocephalus* or *Saukia*. It bears a close resemblance to the genal spines of forms like *Saukia crassimarginata*, Whitfield[2] and *Saukia leucosia*, Walcott[3].

Fam. Dikellocephalidæ.

Genus **Notasaphus**, Gregory.

Notasaphus fergusoni, Gregory. Plate VII., figs. 27–29.

*Dinesus ida*, pars., Etheridge, jun., 1896, Proc. R. Soc. Vict., vol. VIII. (N.S.), pt. I., figs. 5, 6.

*Notasaphus fergusoni*, Gregory, 1902, Proc. R. Soc. Vict., vol. XV. (N.S.), pt. II., p. 155, pl. XXVI., figs. 11–13.

*Observations.*—A comparatively well preserved cranidium occurs in the present collection, which I have no hesitation in referring to the above species. It is more complete than those figured by Prof. Gregory, and shows the large tumid and expanded glabella to be marked with about four faint transverse furrows. There is a well marked frontal border present, and the neck-ring carries a blunt spine.

The pygidia of this species are quite abundant in the Heathcote material. There is a great variation amongst them, but they cannot be separated into any stable sub-species. The spines of the pygidial border vary in number from four to six on each side, corresponding to the number of pygidial segments. The genus most nearly approaches *Dorypyge*, Dames,[4] from which it differs in the form of the glabella, being more expanded in front. *Notasaphus* is further distinguished in the almost obsolete transverse furrows. Although generally held to be Lower and Middle Cambrian, this related genus *Dorypyge* has been regarded by G. F. Matthew and H. Woodward as extending its range into the Upper Cambrian[5]. The pygidia of another genus, *Blackwelderia*,[6] also resemble those of *Notasaphus*, but in the cephalon of that genus the glabella is narrower and tapers anteriorly.

Super-order Branchiopoda.

Order Conchostraca.

Fam. Limnadiidæ.

Genus **Lepeditta**, Matthew.

Lepeditta knowsleyensis, Chapman sp. Plate VII., fig. 30.

(?)*Modiolopsis knowsleyensis*, Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 224, pl. XXI., figs. 11, 12.

*Description.*—Valves semi-elliptical, slightly oblique. Hinge-line straight. Anterior border rather narrowly rounded and sharply curved backwards to meet the dorsal line at an obtuse angle. Ventral margin widely curved, rounded at the posterior, and becoming straight near the junction with the hinge-line. Surface wrinkled parallel to and near the ventral margin. Antero-dorsal area with a compressed border.

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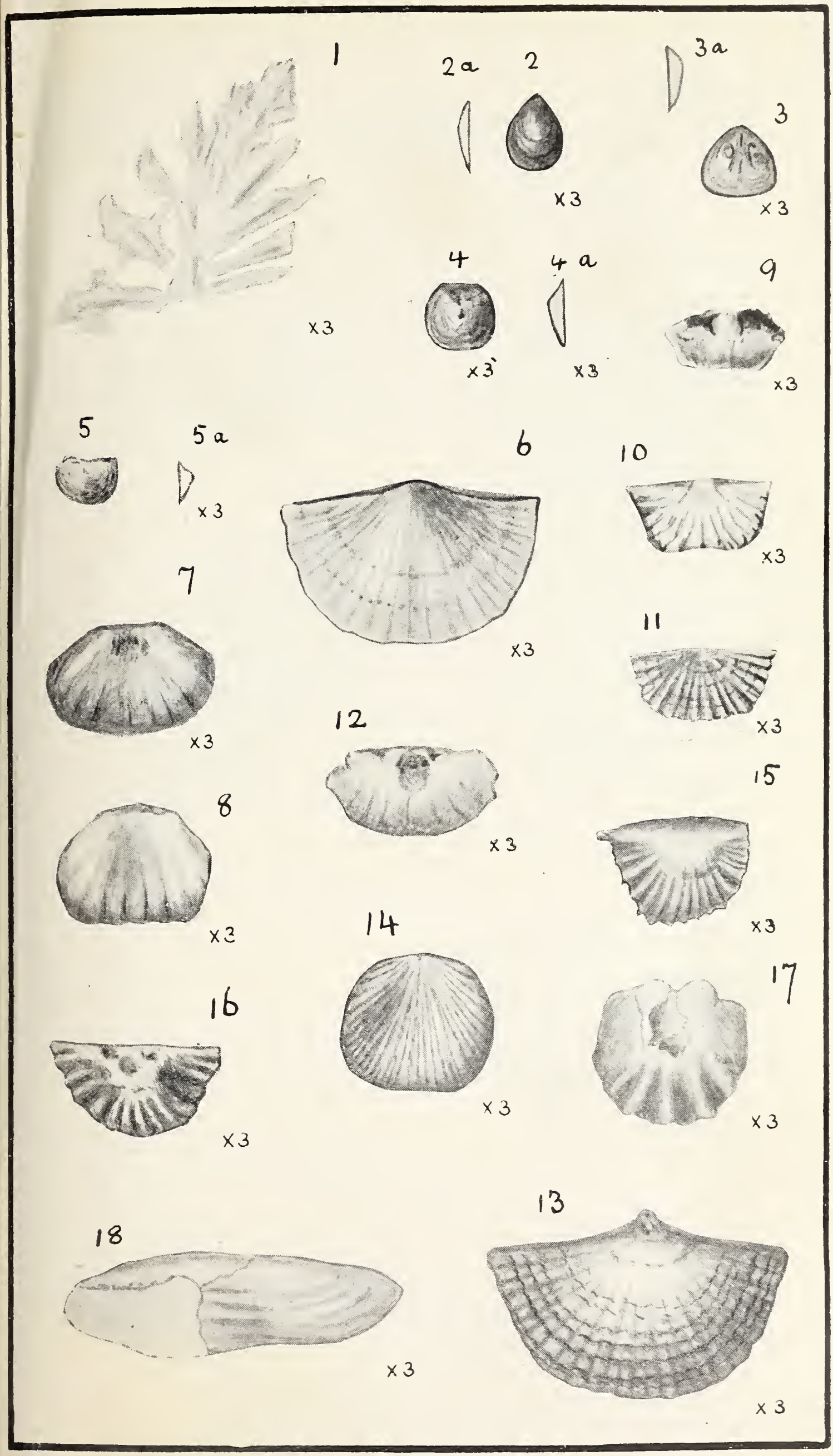
[1] See Walcott, Smithsonian Contrib., vol. LVII., No. 13, 1914, p. 381, pl. LXVII., figs. 1, 4, 5, 7, 8.
[2] *Op. cit.*, p. 377, pl. LXVI., fig. 3.
[3] *Op. cit.*, p. 379, pl. LXVII., fig. 15.
[4] In Richthofen's "China," vol. IV., 1883, p. 28.
[5] H. Woodward. Geol. Mag., 1905, p. 214.
[6] Walcott. Proc. U.S. Nat. Mus., vol. XXX., 1906, p. 573. See also *id.*, Research in China, Carnegie Institution publ., No. 54, vol. III., 1913, pp. 116–123, pl. IX., f. 5–7.

PLATE VI.

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CAMBRIAN FOSSILS FROM HEATHCOTE, VICTORIA.

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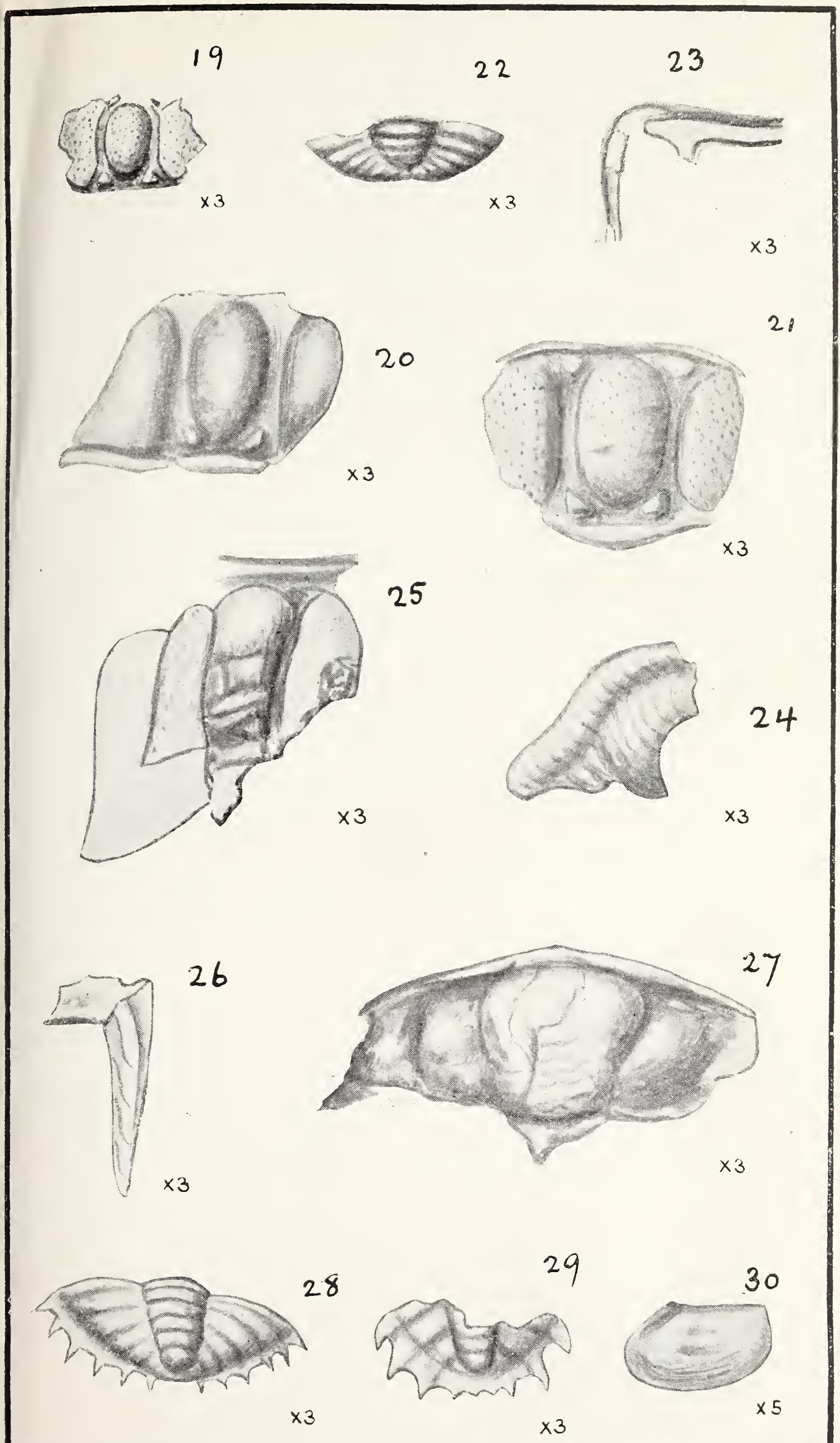
PLATE VII.

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*Dimensions.*—Length, 4·2 mm. ; greatest height, 2·4 mm.

*Observations.*—The thin chitinous-looking remains of this fossil make it referable to the crustacea rather than to the mollusca. It does not fall into *Hymenocaris* on account of the minute size and only partially oblique contour ; whilst the posterior is not so produced and pointed as in that genus. From the ostracod *Leperditia* it differs in the apparently chitinous character of the carapace, otherwise it resembles some species of the genus like *Leperditia canadensis*, Jones.

Its nearest analogue appears to be *Lepeditta alata*, Matthew.[1]

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## Explanation of Plates.

### Plate VI.

Fig. 1. *Sphenothallus filicoides*, sp. nov. Skeats coll. × 3.

Fig. 2. *Lingulella australis*, sp. nov. 2*a*, profile. M.D. coll.[2] (7785). × 3.

Fig. 3. *Leptobolus truncata*, sp. nov. Pedicle valve. 3*a*, profile. M.D. coll. (7836). × 3.

Fig. 4. *Acrothele subquadrata*, sp. nov. Pedicle valve. 4*a*, profile. M.D. coll. (7812). × 3.

Fig. 5. *Acrothele brevis*, sp. nov. Pedicle valve. 5*a*, profile. M.D. coll. (7929). × 3.

Fig. 6. *Billingsella tenera*, Chapman sp. Pedicle valve. M.D. coll. (304). × 3.

Fig. 7. *Billingsella fergusoni*, sp. nov. Holotype. Brachial valve. M.D. coll. (7838). × 3.

Fig. 8. *Billingsella fergusoni*, sp. nov. Paratype. Pedicle valve. M.D. coll. (307). × 3.

Fig. 9. *Billingsella fergusoni*, sp. nov. A cast. M.D. coll. (7799). × 3.

Fig. 10. *Eoörthis flexilis*, sp. nov. Co-type. Natural cast of pedicle valve. M.D. coll. (7910). × 3.

Fig. 11. *Eoörthis flexilis*, sp. nov. Co-type. From a wax squeeze of a mould of the same valve. M.D. coll. (7911). × 3.

Fig. 12. *Hebertella raristriata*, Chapman. Cast of a brachial valve. M.D. coll. (7786). × 3.

Fig. 13. *Eostrophomena skeatsi*, sp. nov. Pedicle valve. Skeats coll. × 3.

Fig. 14. *Huenella divaricata*, Chapman sp. Brachial valve. Plesiotype. M.D. coll. (7924). × 3.

Fig. 15. *Clitambonites flabelloides*, Chapman sp. Pedicle valve. Squeeze from mould. M.D. coll. (7783). × 3.

Fig. 16. Ditto. Pedicle valve. M.D. coll. (7909). × 3.

Fig. 17. Ditto. Pedicle valve with few plicæ. M.D. coll. (7893). × 3.

Fig. 18. *Grammysia heathcotiensis*, sp. nov. M.D. coll. (7940). × 3.

### Plate VII.

Fig. 19. *Dinesus ida*, Etheridge fil. A small cranidium, showing typical granulated surface. M.D. coll. (7859). × 3.

Fig. 20. Ditto. A smooth (? decorticated) cranidium, showing neck ring and basal lobes. M.D. coll. (7849). × 3.

Fig. 21. Ditto. A well preserved cranidium showing granulate surface, anterior and posterior lobes and furrowed glabella ; also frontal limb. M.D. coll. (7931). × 3.

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[1] Trans. R. Soc., Canada, vol. III., 1886, p. 61, pl. VI., figs. 16, 16*a*.

[2] M.D. coll. signifies Mines Department collection.

Fig. 22. ?*Dinesus ida*, Eth. fil. A pygidium. M.D. coll. (7800). × 3.

Fig. 23. *Saratogia* cf. *hamulus*, Owen sp. Fragmentary cast of a genal spine. M.D. coll. (7792). × 3.

Fig. 24. ?*Saratogia rugulata*, sp. nov. A free cheek. M.D. coll. (7886). × 3.

Fig. 25. cf. *Saukia* sp. A cranidium resembling *S. pepinensis*, Owen sp. M.D. coll. (7802). × 3.

Fig. 26. cf. *Saukia* sp. A genal spine. M.D. coll. (7795). × 3.

Fig. 27. *Notasaphus fergusoni*, Gregory. A nearly complete cranidium, showing neck ring, and faint transverse furrows. M.D. coll. (7926). × 3.

Fig. 28. Ditto. Pygidium with rather numerous spines. M.D. coll (7791). × 3.

Fig. 29. Ditto. Pygidium with few spines of a stouter character than the foregoing specimen, and with narrower axis. M.D. coll. (7810). × 3.

Fig. 30. *Lepeditta knowsleyensis*, Chapman sp. A wax squeeze taken from interior of valve. M.D. coll. (308). × 5.

# PRELIMINARY NOTES ON NEW SPECIES OF SILURIAN AND DEVONIAN FOSSILS FROM NORTH-EAST GIPPSLAND.

*By Frederick Chapman, A.L.S., &c., Palæontologist to the National Museum, Melbourne.*

## ALGÆ.

### Sphaerocodium gippslandicum, sp. nov.

*Description.*—Thallus forming fungiform pellets, consisting of fasciculated masses of radiating, dichotomously branched, single-celled filaments. Cells ovoid or short cylindrical, measuring about ·15 mm. in diameter. A typical pellet measures about 5 mm. in diameter.

*Occurrence.*—In compact blue limestone associated with *Diphyphyllum robustum*, Eth. fil., of Middle Devonian age. Junction of Wombat Creek and the Mitta Mitta River, N.E. Gippsland.

## POLYZOA.

### Fistulipora cowombatensis, sp. nov.

*Description.*—Zoarium cylindrical or sub-rotund. Length of one example 28 mm.; diameter, 13·5 mm. In horizontal section the zooecia are circular, and average ·6 mm. in diameter. The mesopores are smaller, angular to lobate, and average 1 mm. in diameter. Walls of both zooecia and mesopores thin; numerously perforated. In longitudinal section the mesopores are seen to be short and broad proportionally.

*Occurrence.*—In fossiliferous Silurian limestone, Cowombat Creek, N.E. Gippsland.

### Acanthoclema flexuosa, sp. nov.

*Description.*—Zoarium moderately slender and branching; branches cylindrical or slightly flattened; basal portion swollen. Diameter of branches, 2 to 4 mm. Apertures circular to ovate, inclined to be ostiolate, arranged in a vertical series more or less quincuncially. Number of rows usually about ten. Interspaces between the apertures occupied by a depressed vertical ridge. Zoœcia disposed at an acute angle to the axis, but opening at the surface nearly at right angles. The primitive part of the zooecia bend sharply down to the axis. Acanthopores numerous, producing a roughened surface, as seen in well-preserved moulds. Length of zoarium reaching 5 cm. or more.

*Occurrence.*—As well-preserved casts and moulds in indurated dark-grey Silurian shales, Gibbo River, Mitta Mitta, N.E. Gippsland.

## BRACHIOPODA.

### Orbiculoidea diminuens, sp. nov.

*Description.*—Shell minute; upper or ventral valve circular, depressed, with a slightly sub-central pedicle notch. Surface of valve having eleven or more concentric and rounded ridges, with interspaces deeply excavated. Greatest width, 3·25 mm.

*Occurrence.*—In fossiliferous shaly Silurian mudstone, Wombat Creek, N.E. Gippsland.

COELOSPIRA AUSTRALIS, sp. nov.

*Description.*—Dorsal valve nearly hemispherical, with a straight hinge-line, relatively high area, and widely rounded anterior border. The slightly convex surface is medially sulcate and ornamented with about eight broad, bifurcating riblets, the lateral ones strongly incurved in the median area. Both riblets and interspaces are marked with fine raised concentric threads. Ventral valve moderately convex, with about ten rounded or sub-acute riblets, bifurcating near the anterior margin, and crossed with concentric growth lines, which become slightly tegulate anteriorly. Spec. A: length, 5 mm.; width, 7·25 mm. Spec. B: length, 5 mm.; width, 7 mm.

*Occurrence.*—In calcareous Silurian shales, Mitta Mitta River. Also in dark mudstone, Cowombat, near Forest Hill, N.E. Gippsland.

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